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(54) **STACKED FIBER OPTIC MODULES AND FIBER OPTIC EQUIPMENT CONFIGURED TO SUPPORT STACKED FIBER OPTIC MODULES**

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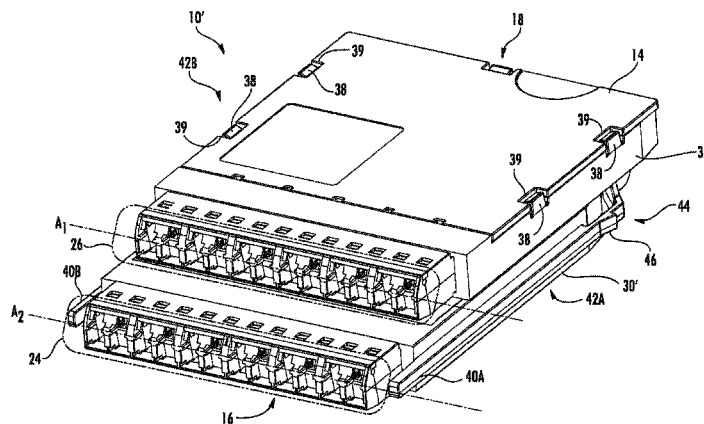
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(57) **ABSTRACT**

Embodiments disclosed in the detailed description include stacked fiber optic modules and fiber optic equipment supporting stacked fiber optic modules. In one embodiment, a stacked fiber optic module is provided. This embodiment of the stacked fiber optic module comprises a body having a first sub-body and a second sub-body where the second sub-body can translate relative to the first sub-body. The stacked fiber optic module further comprises a first plurality of fiber optic components disposed in a first longitudinal axis in the at least one front side. The stacked fiber optic module also further comprises a second plurality of fiber optic components disposed adjacent the first plurality of fiber optic components in a second longitudinal axis parallel or substantially parallel to the first longitudinal axis in the at least one front side.

**19 Claims, 24 Drawing Sheets**



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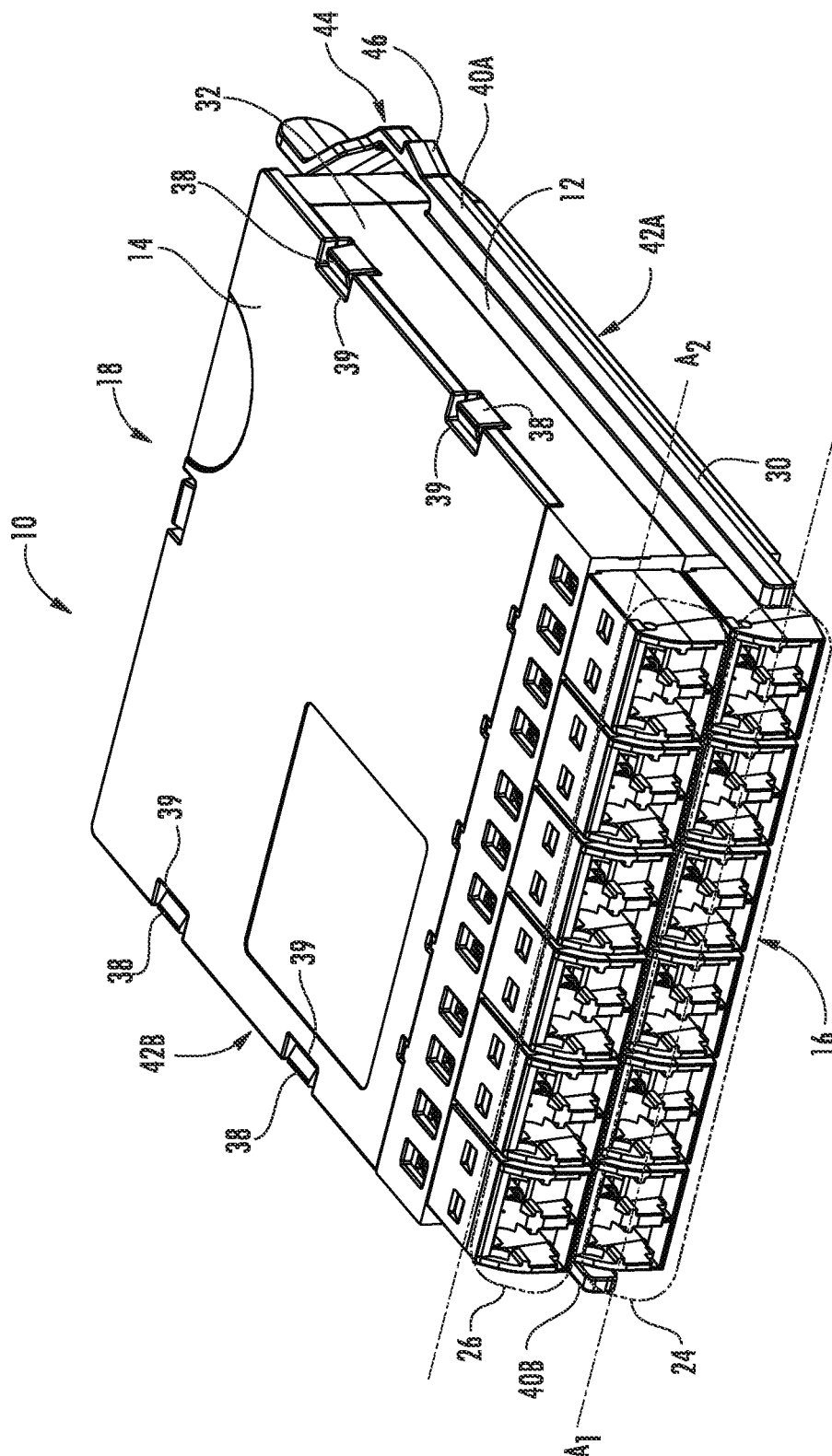


FIG. 1

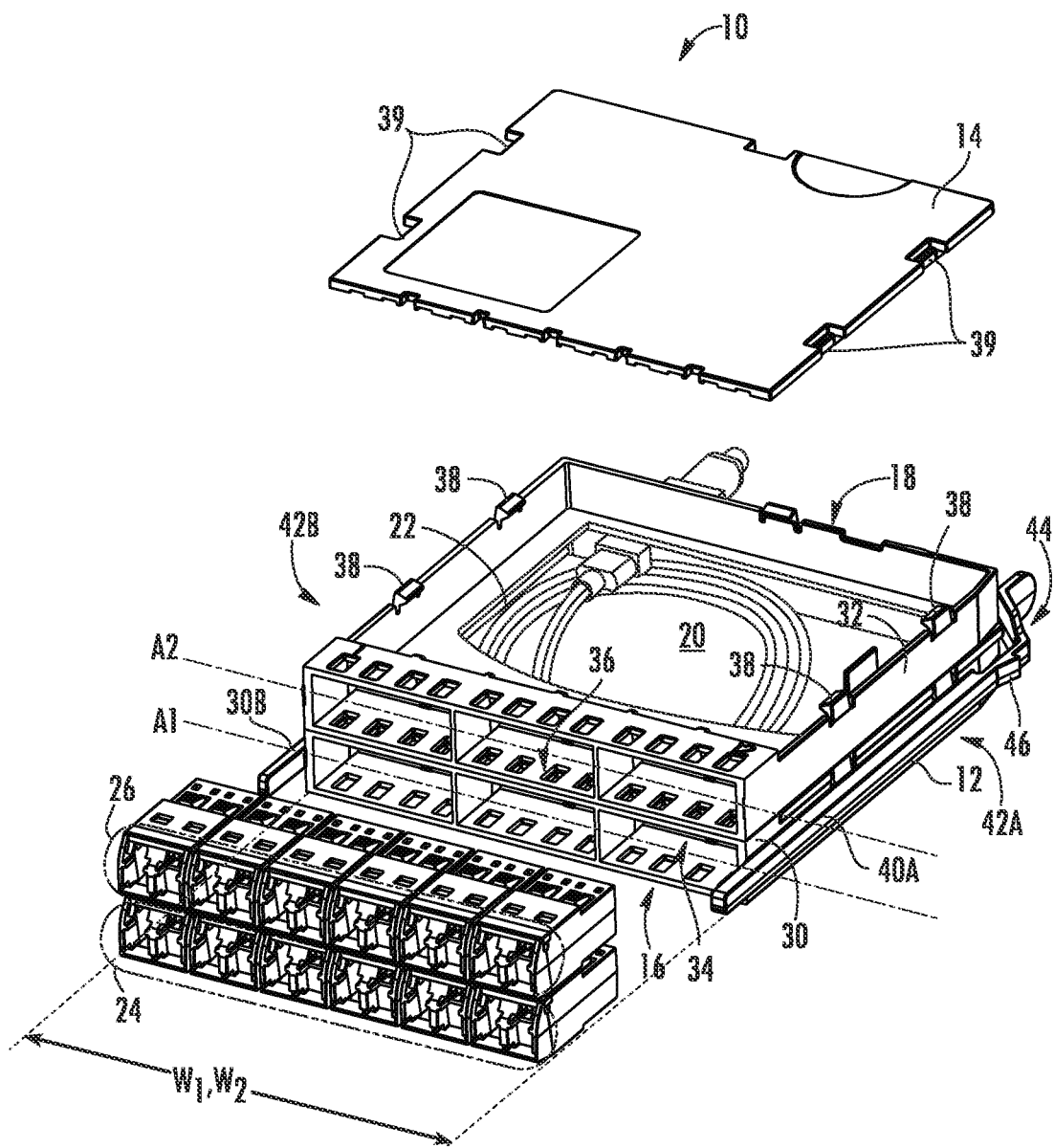


FIG. 2

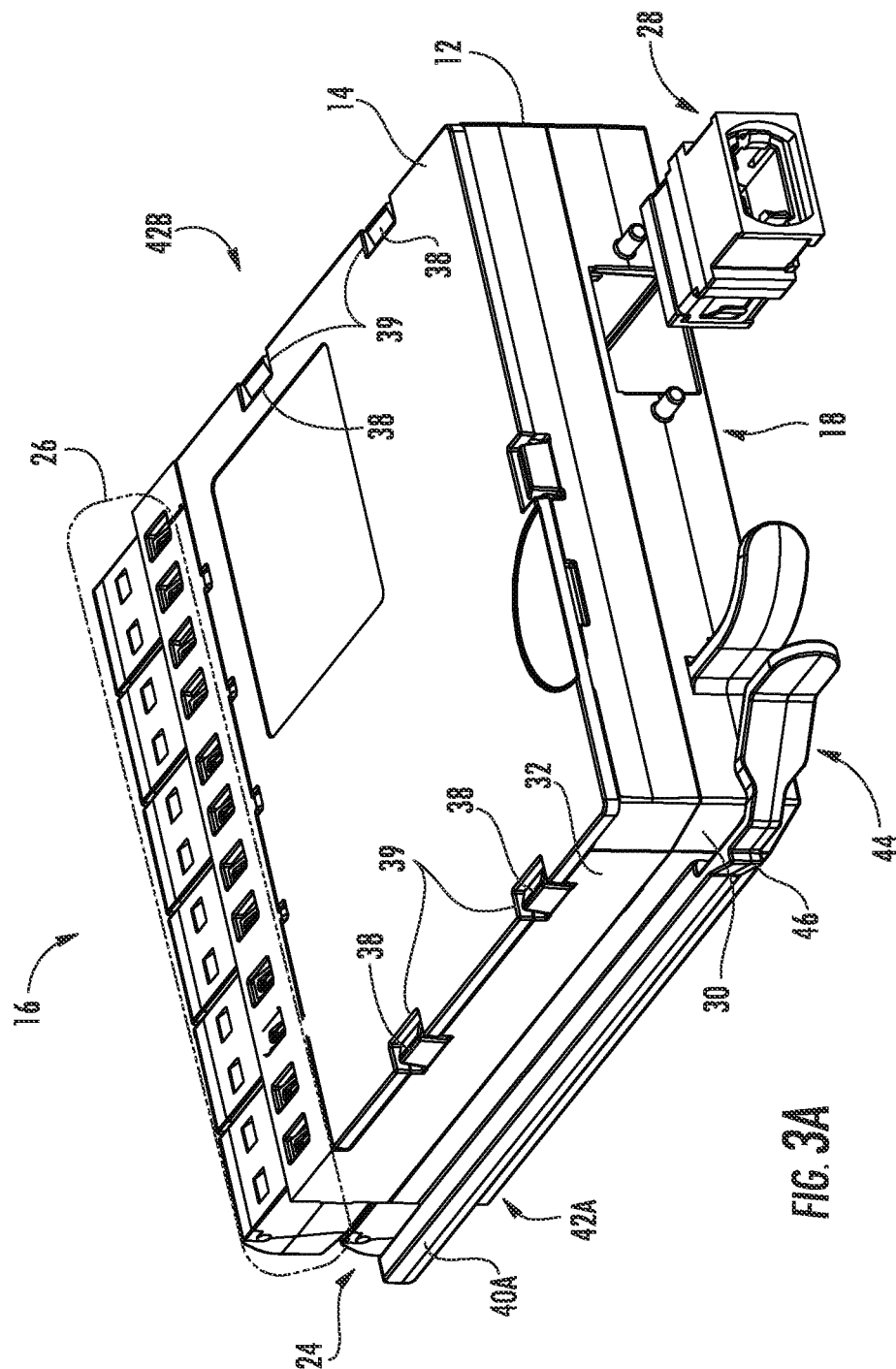
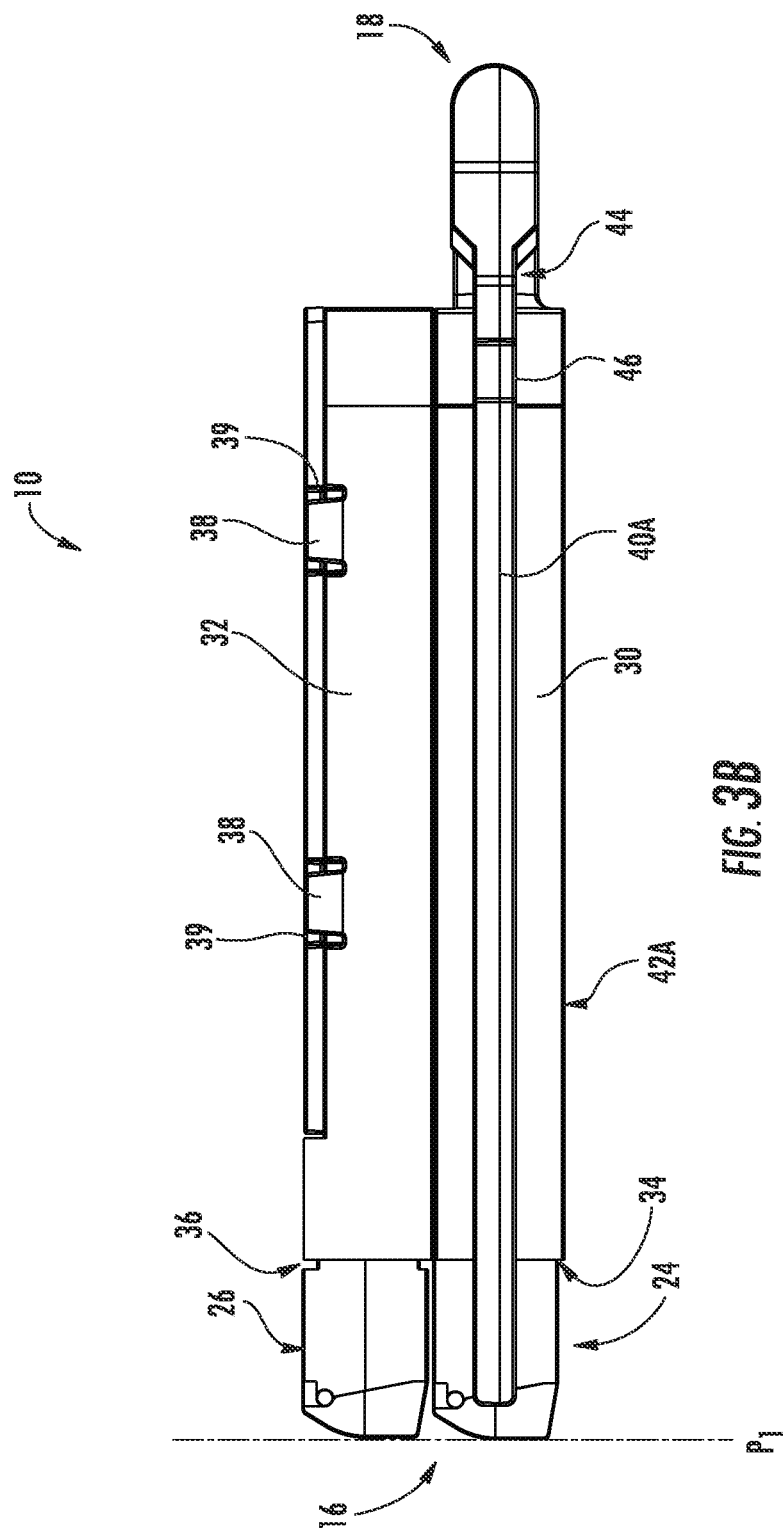
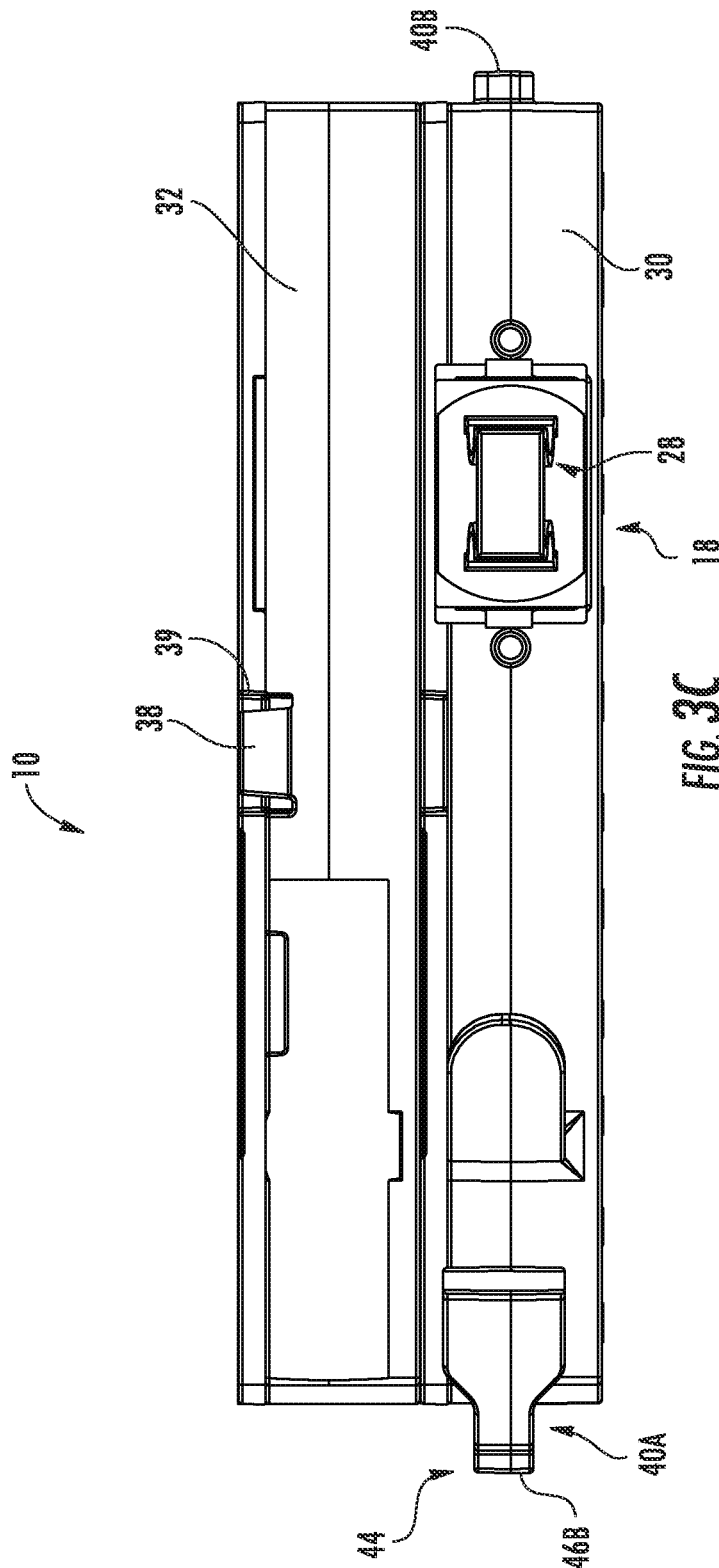
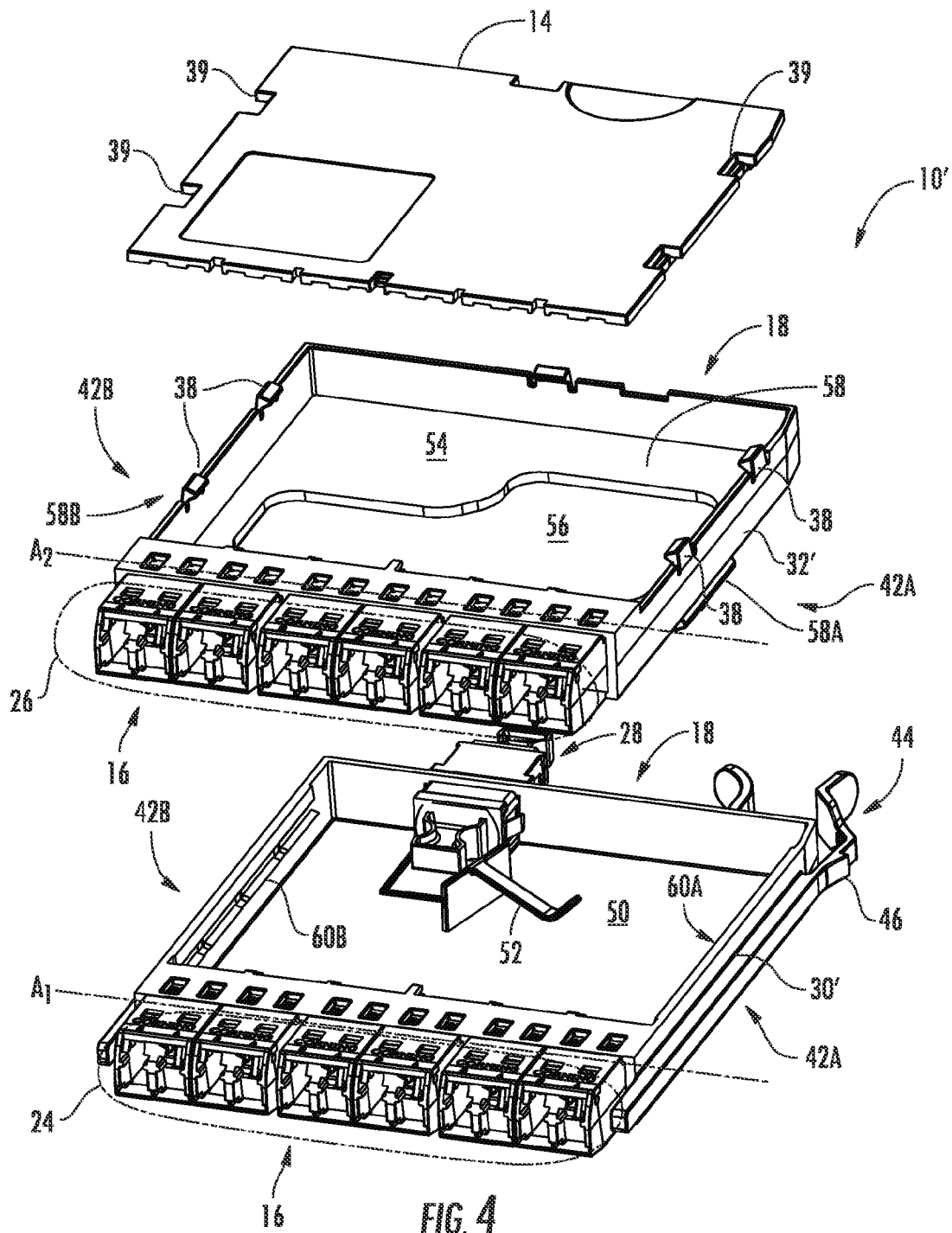


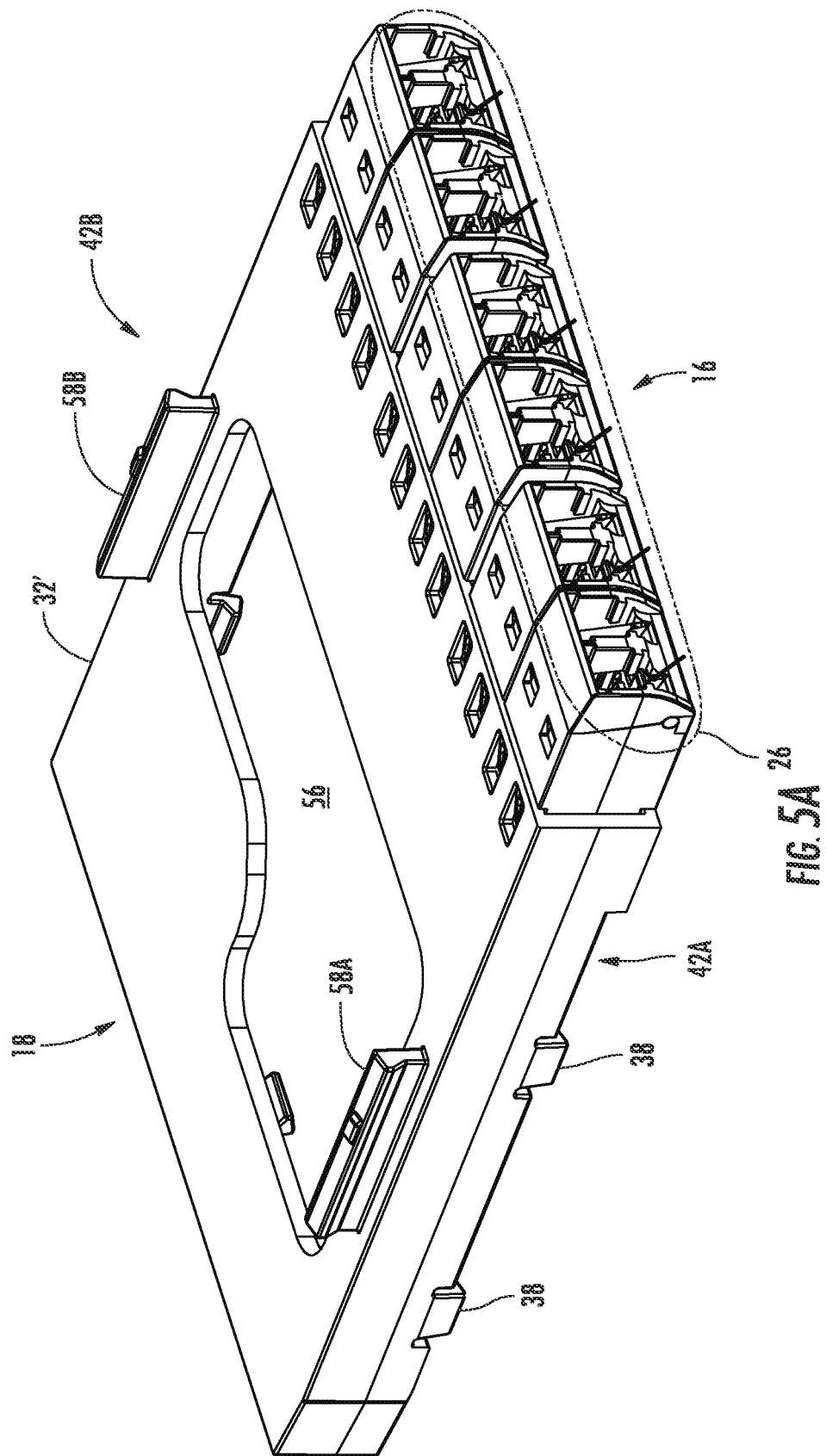
FIG. 3A

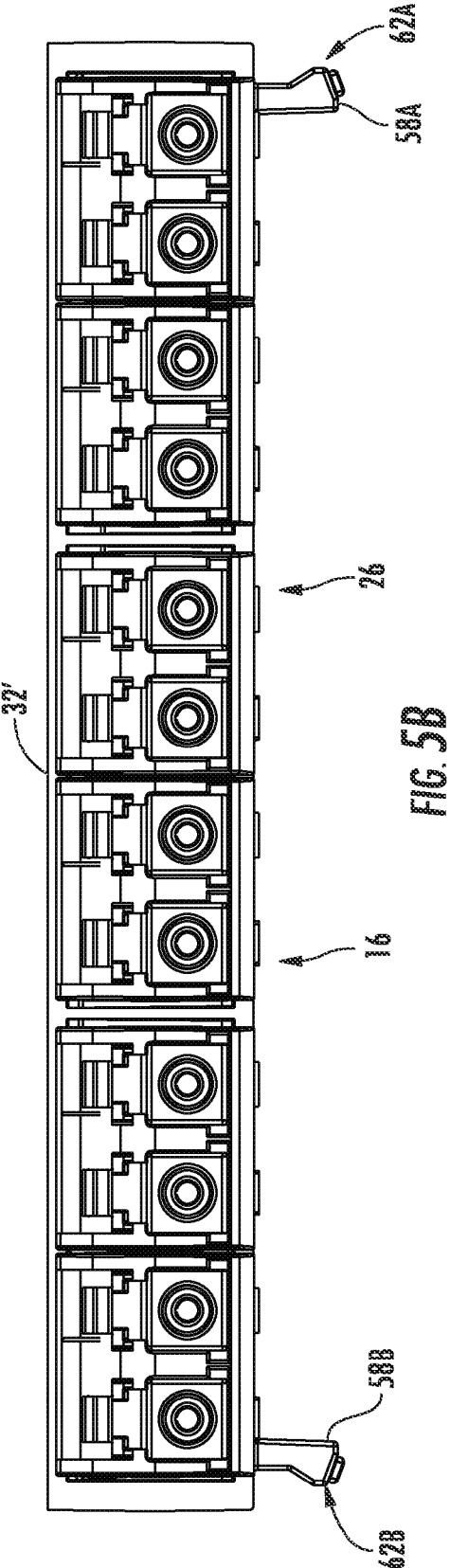












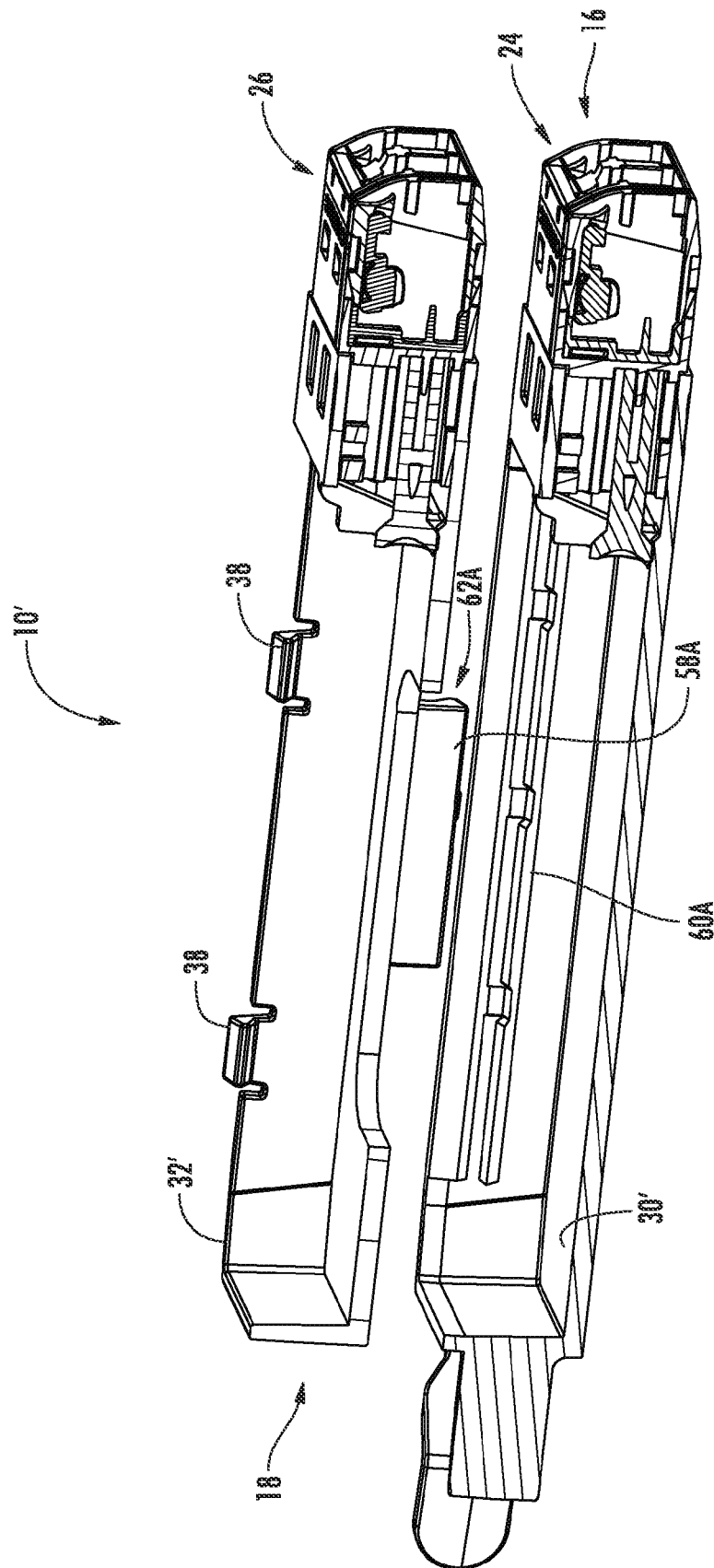


FIG. 6A

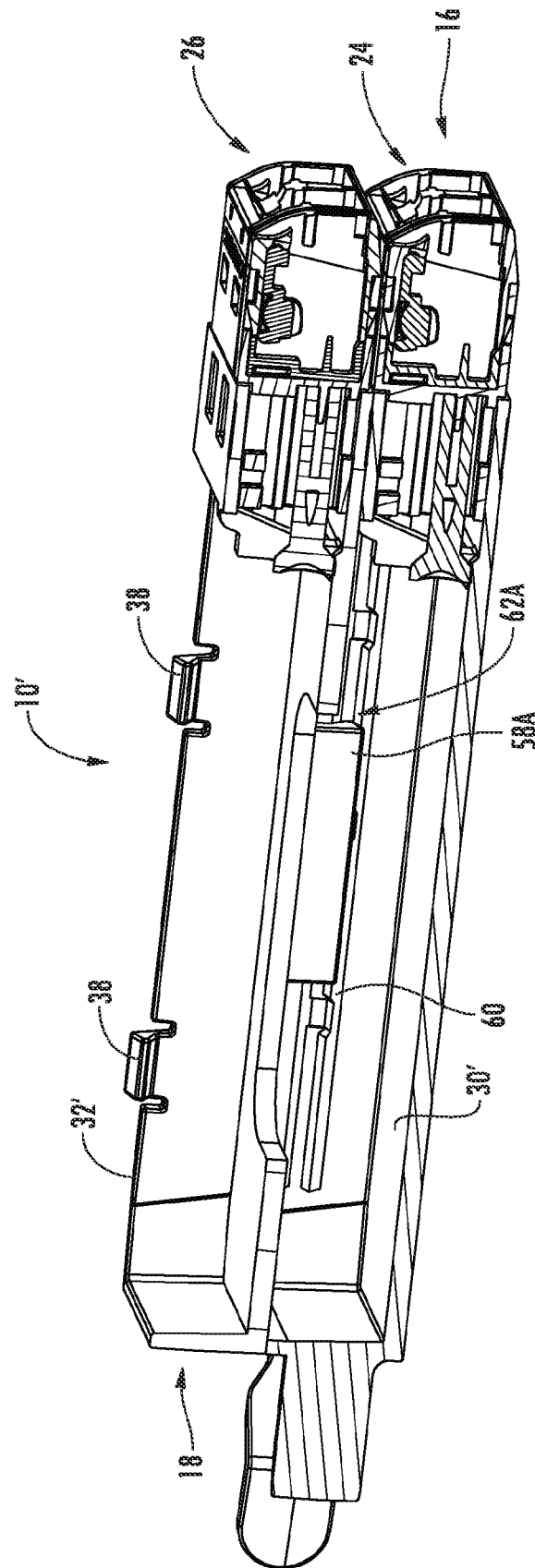
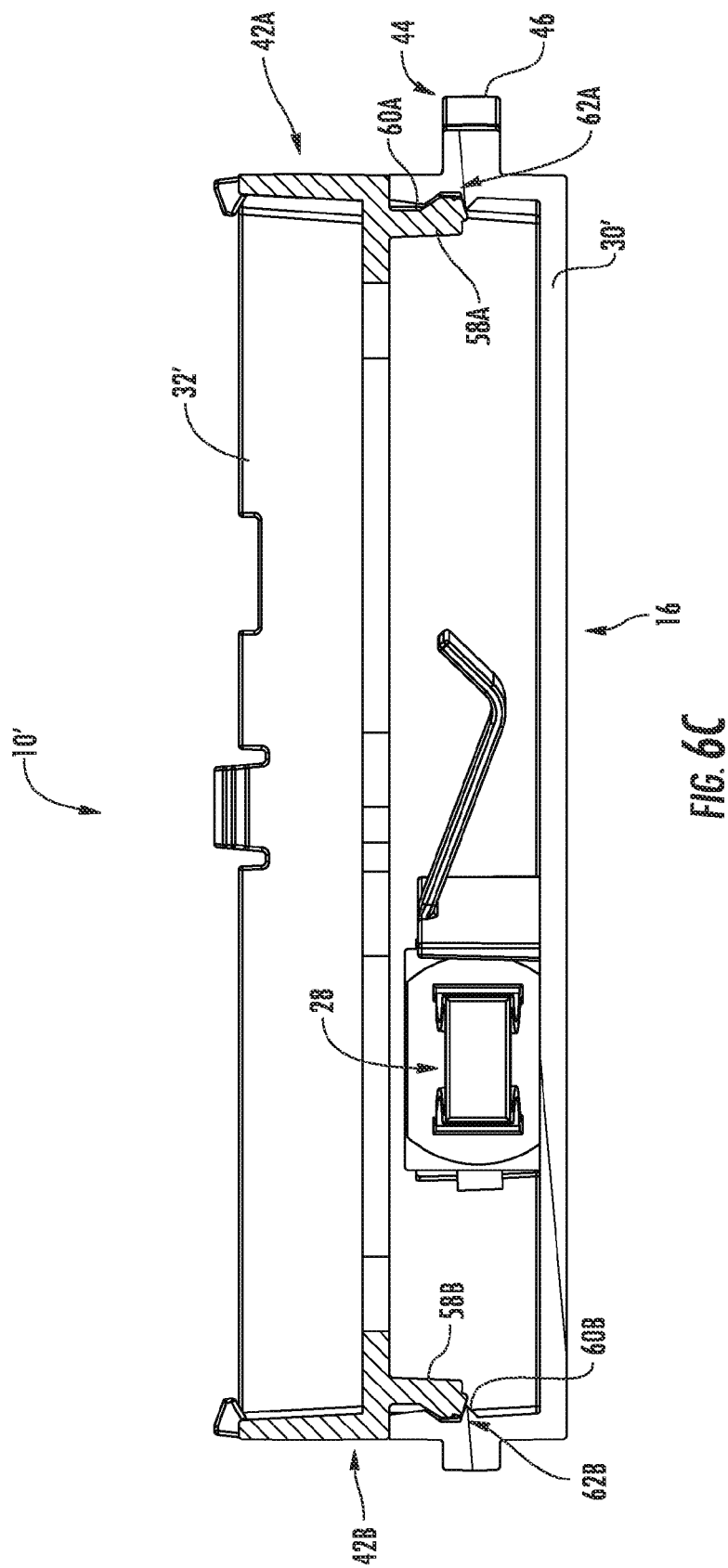
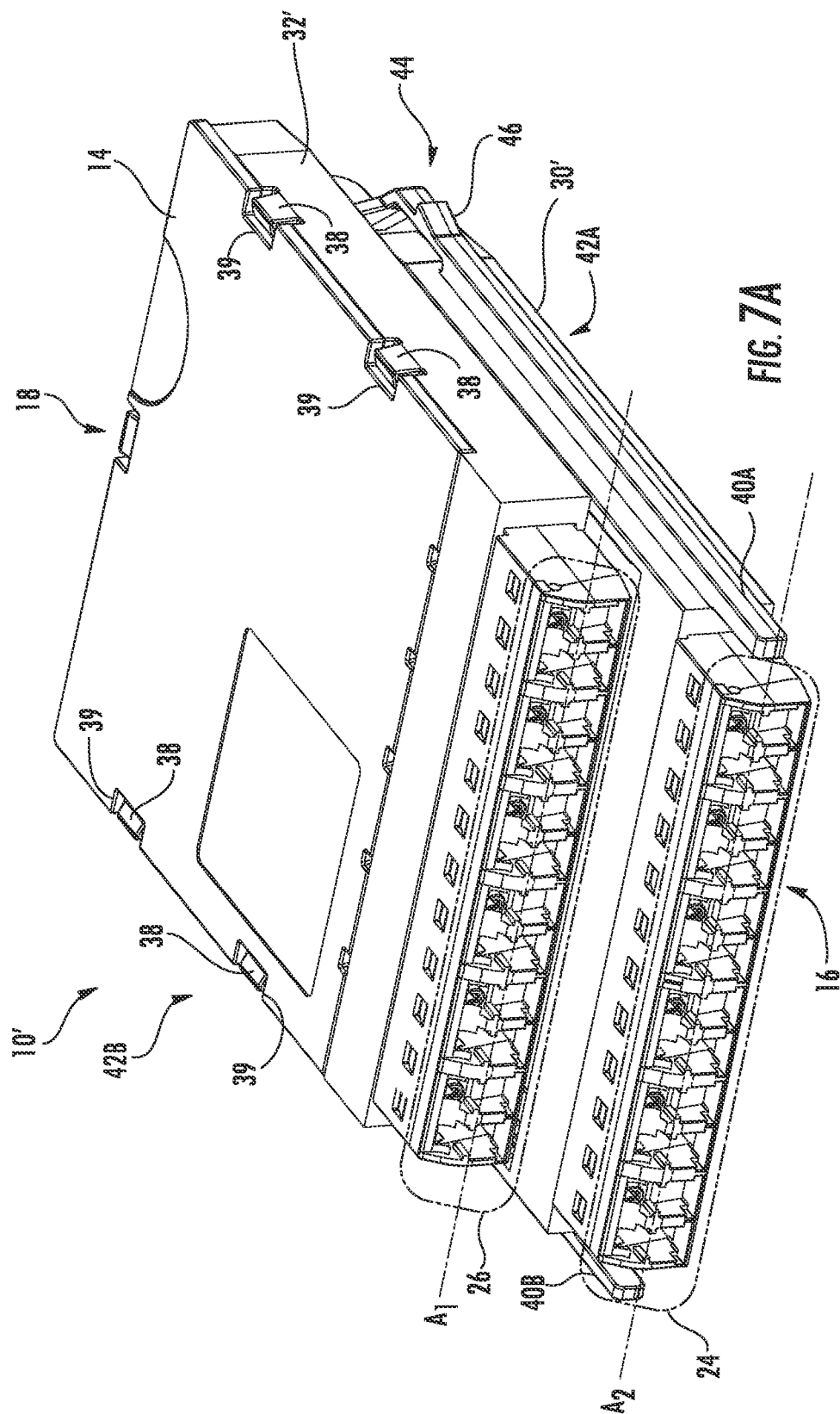
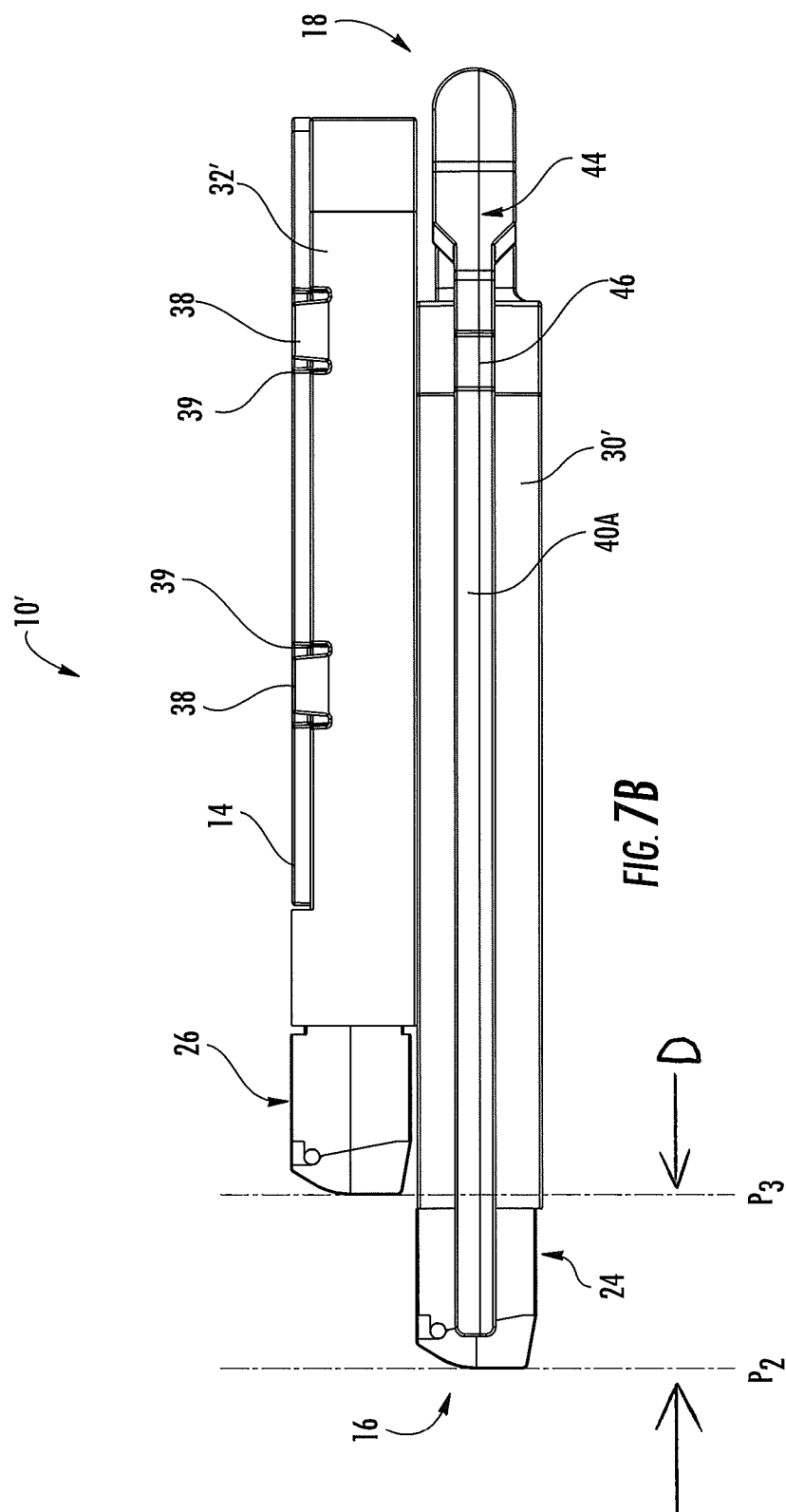


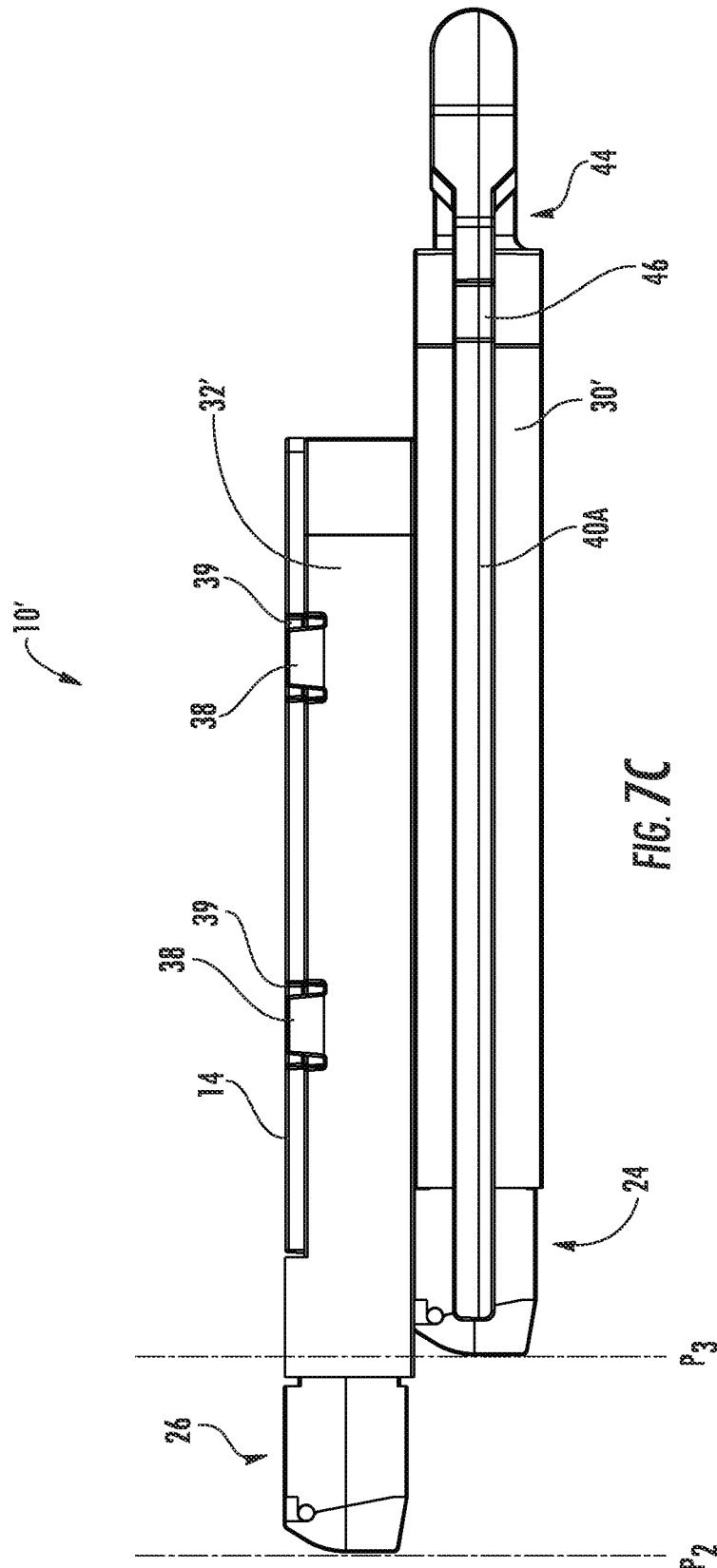
FIG. 6B

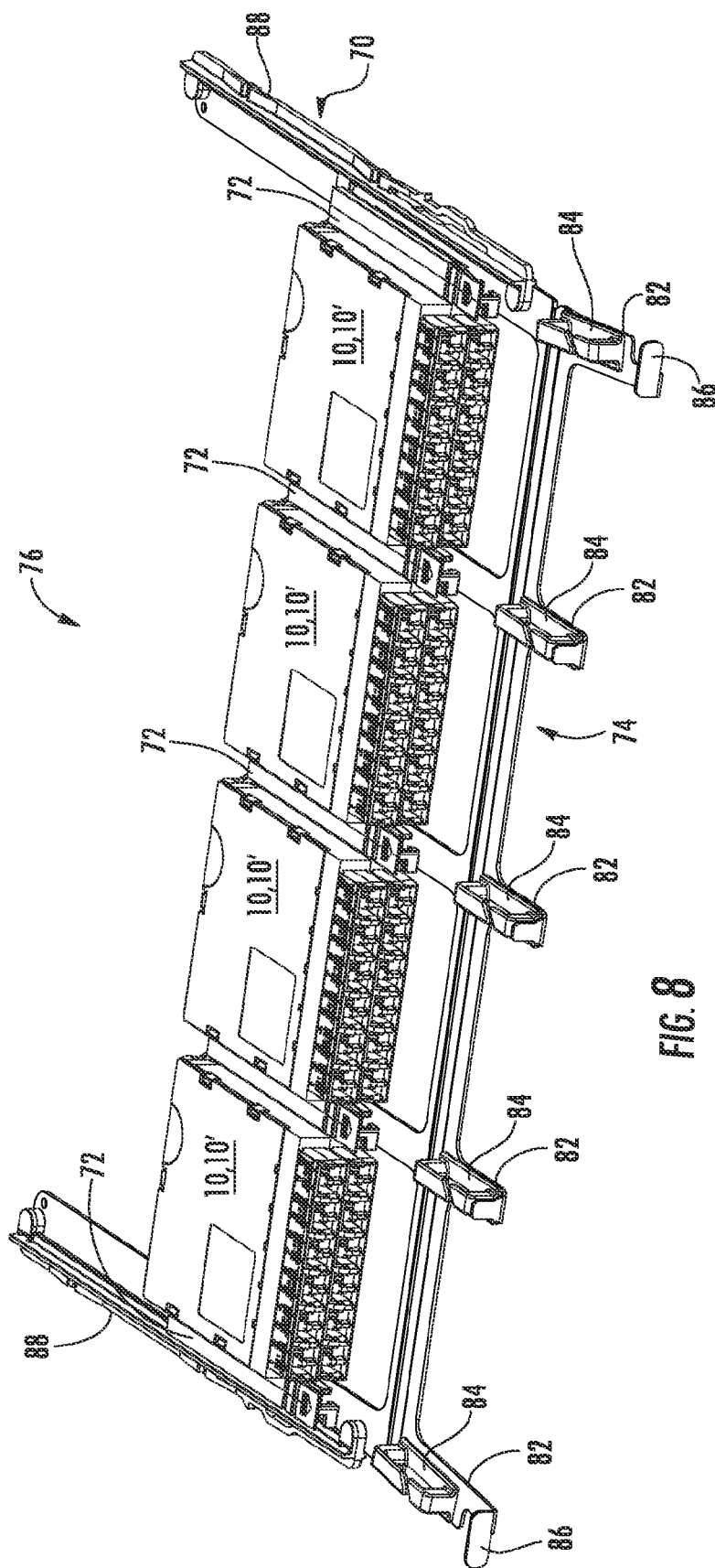


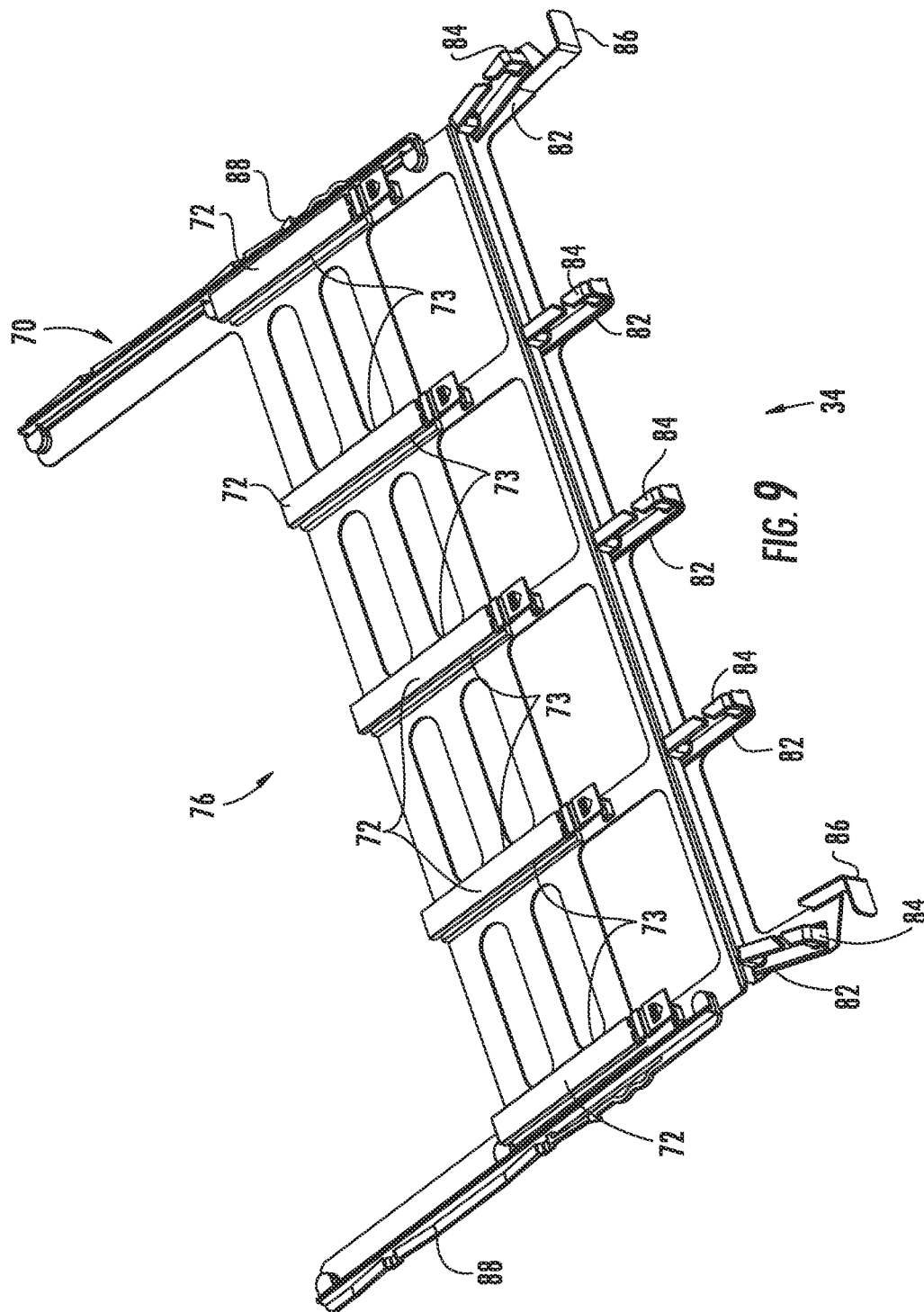


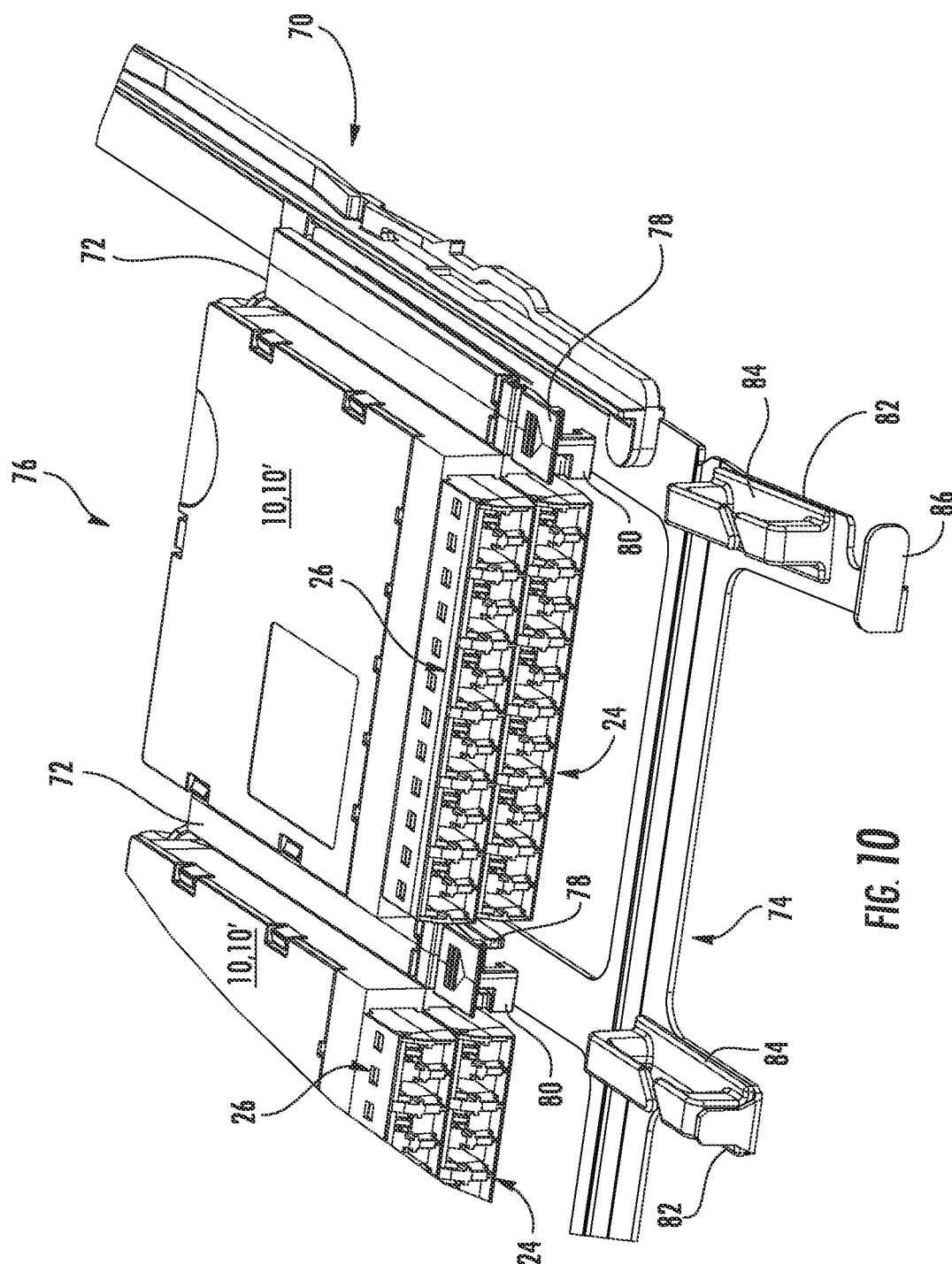












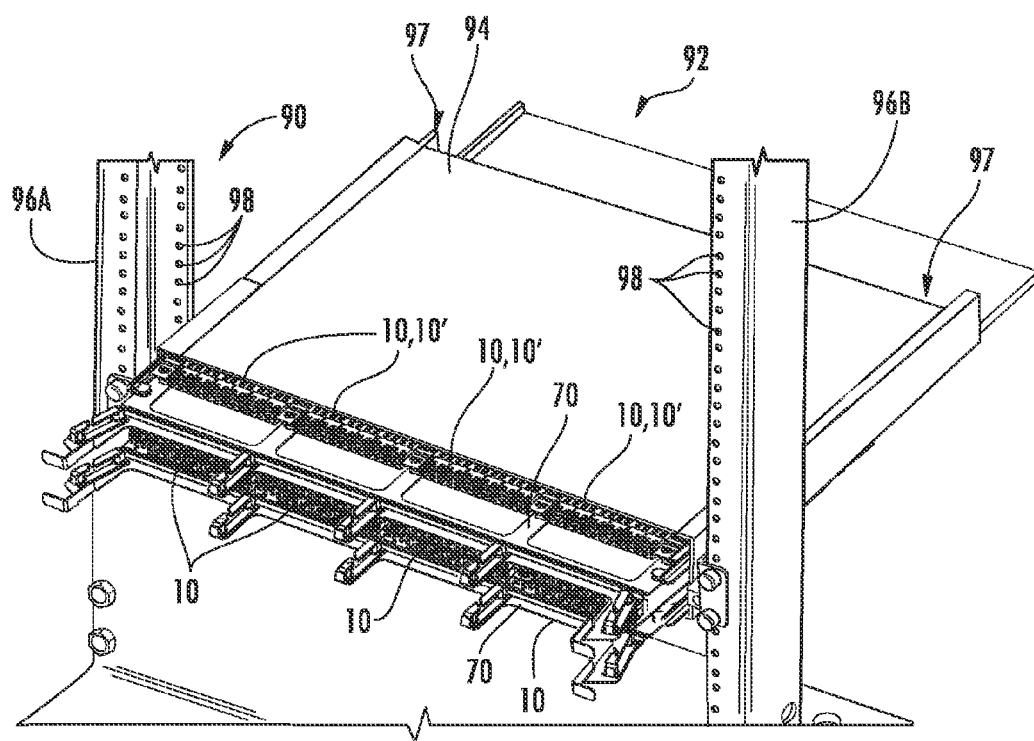
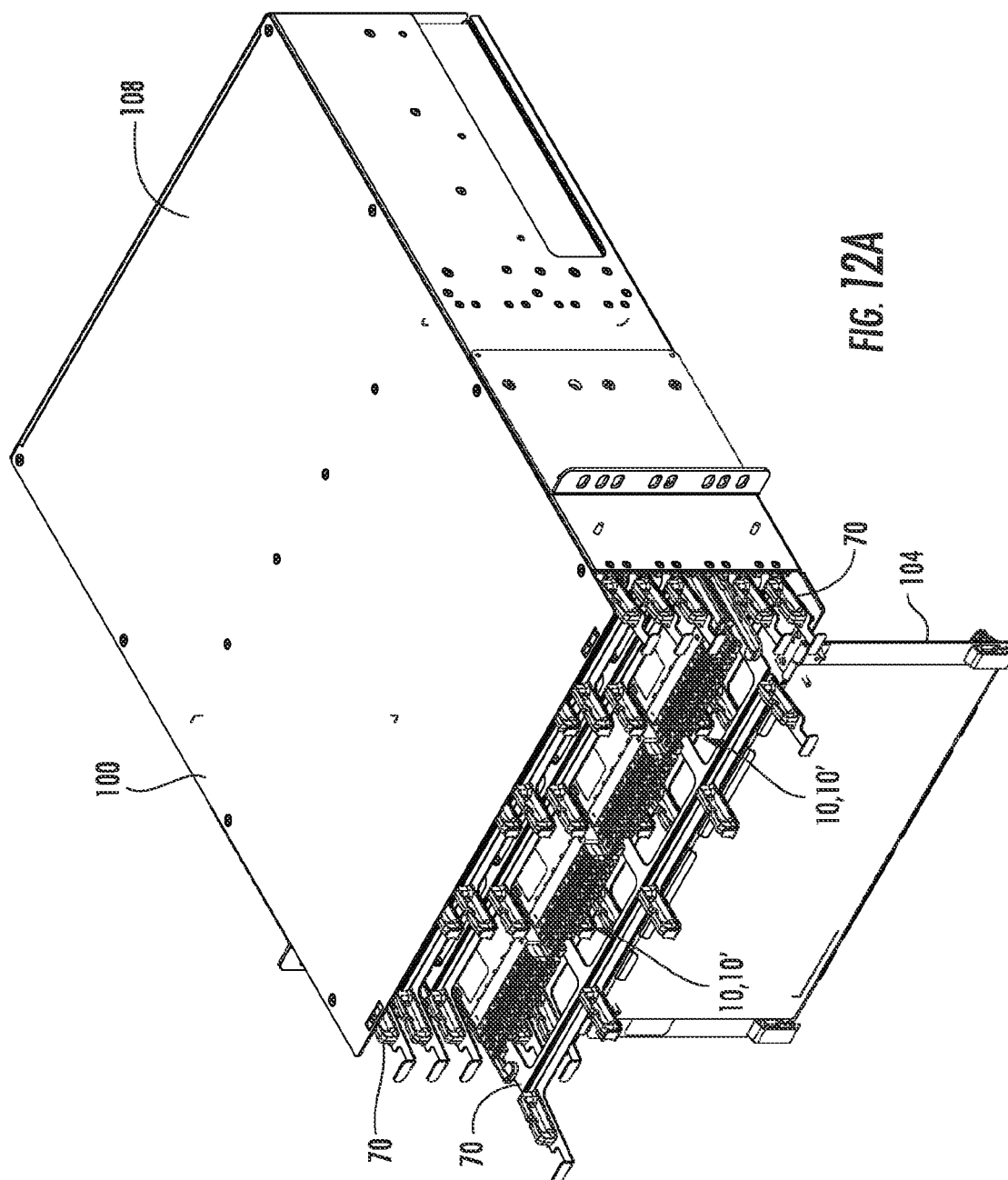
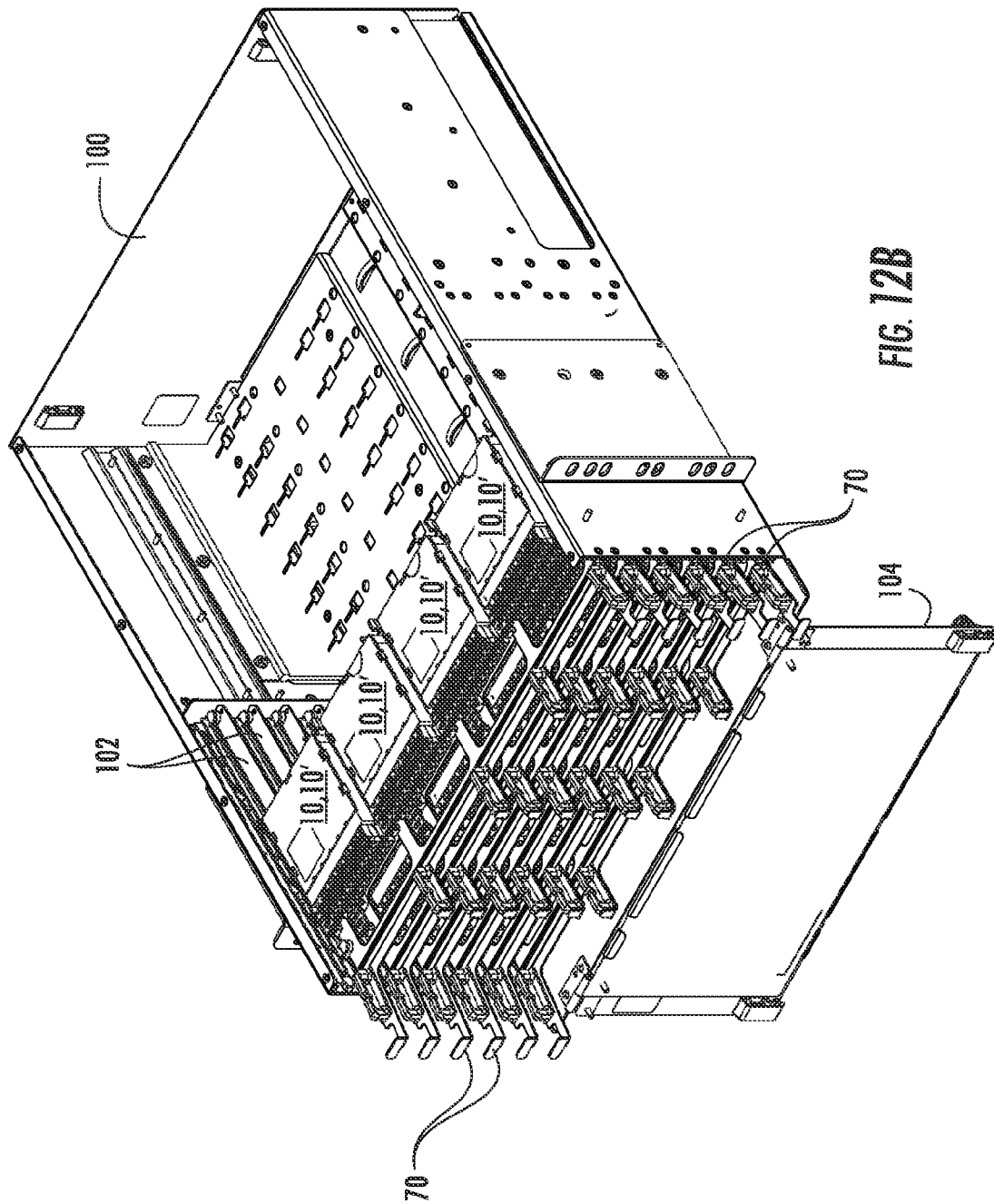
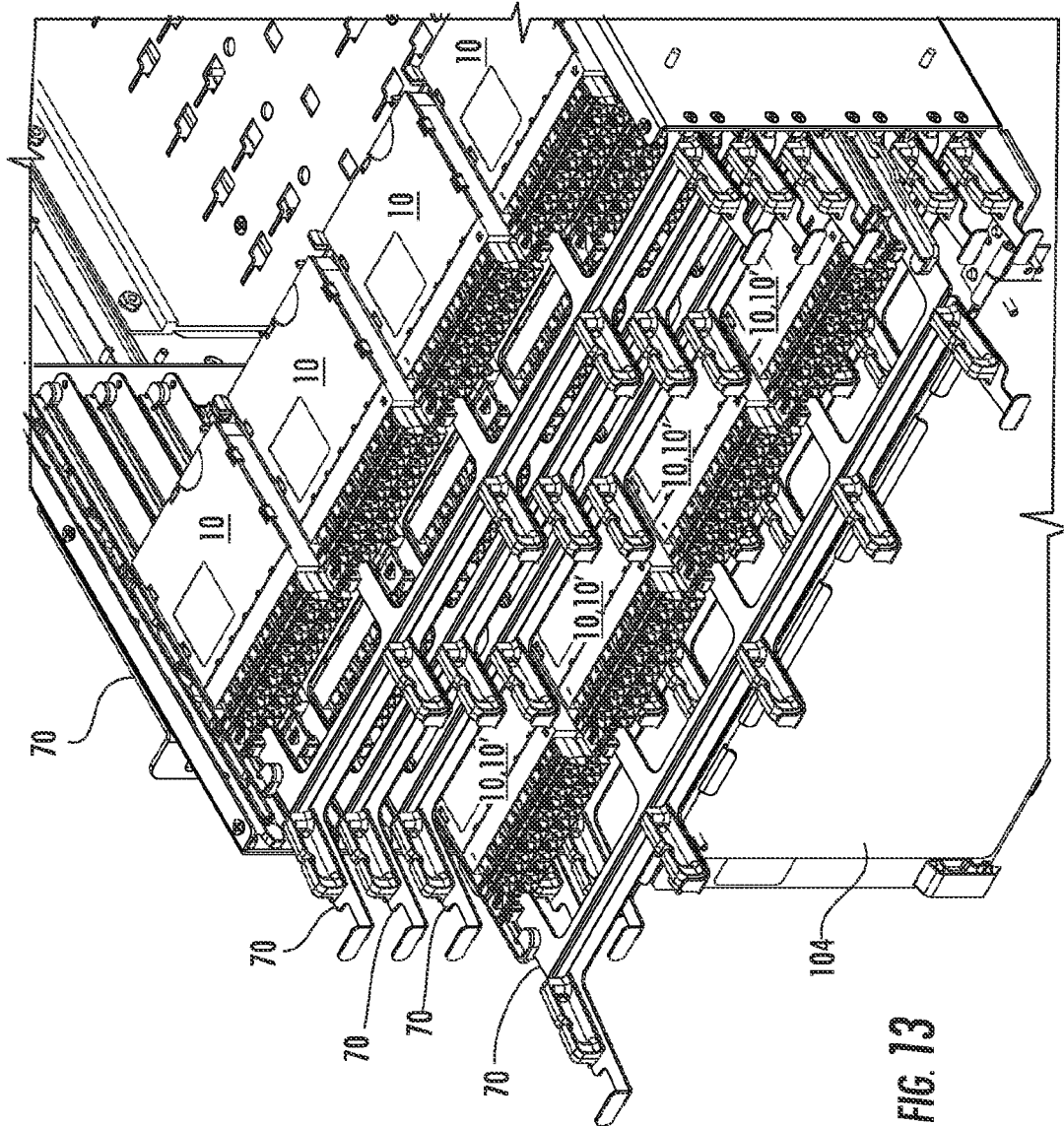


FIG. 11









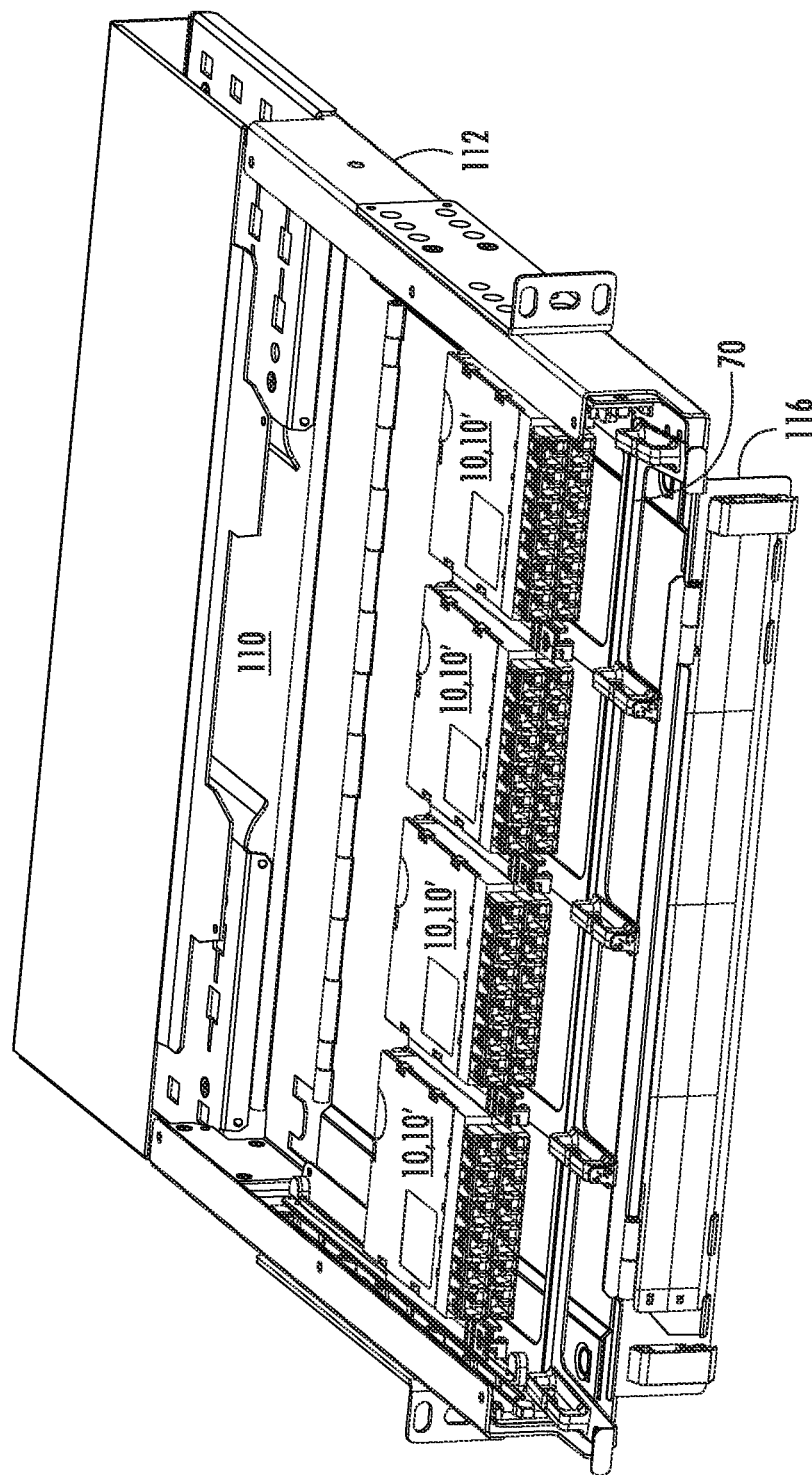
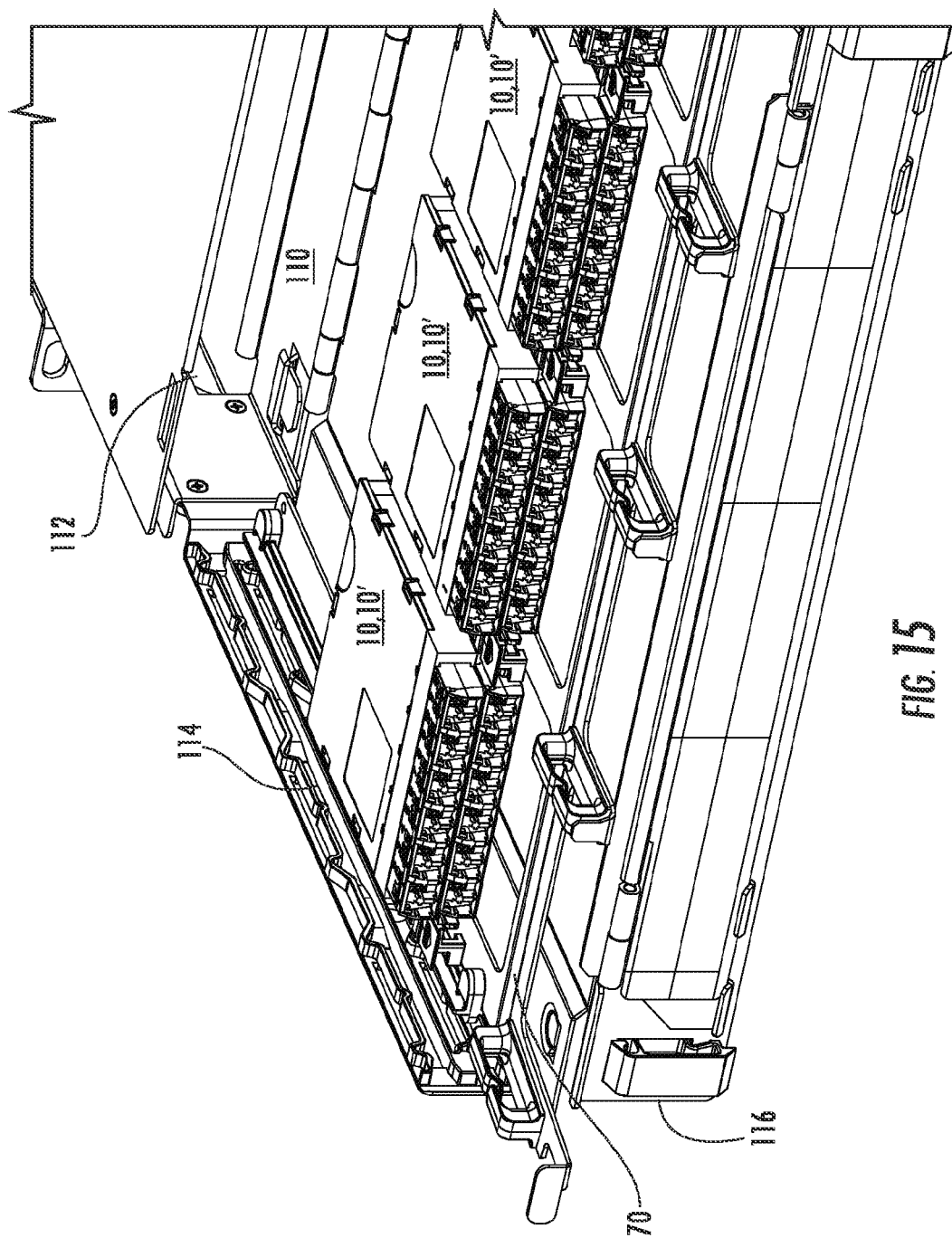
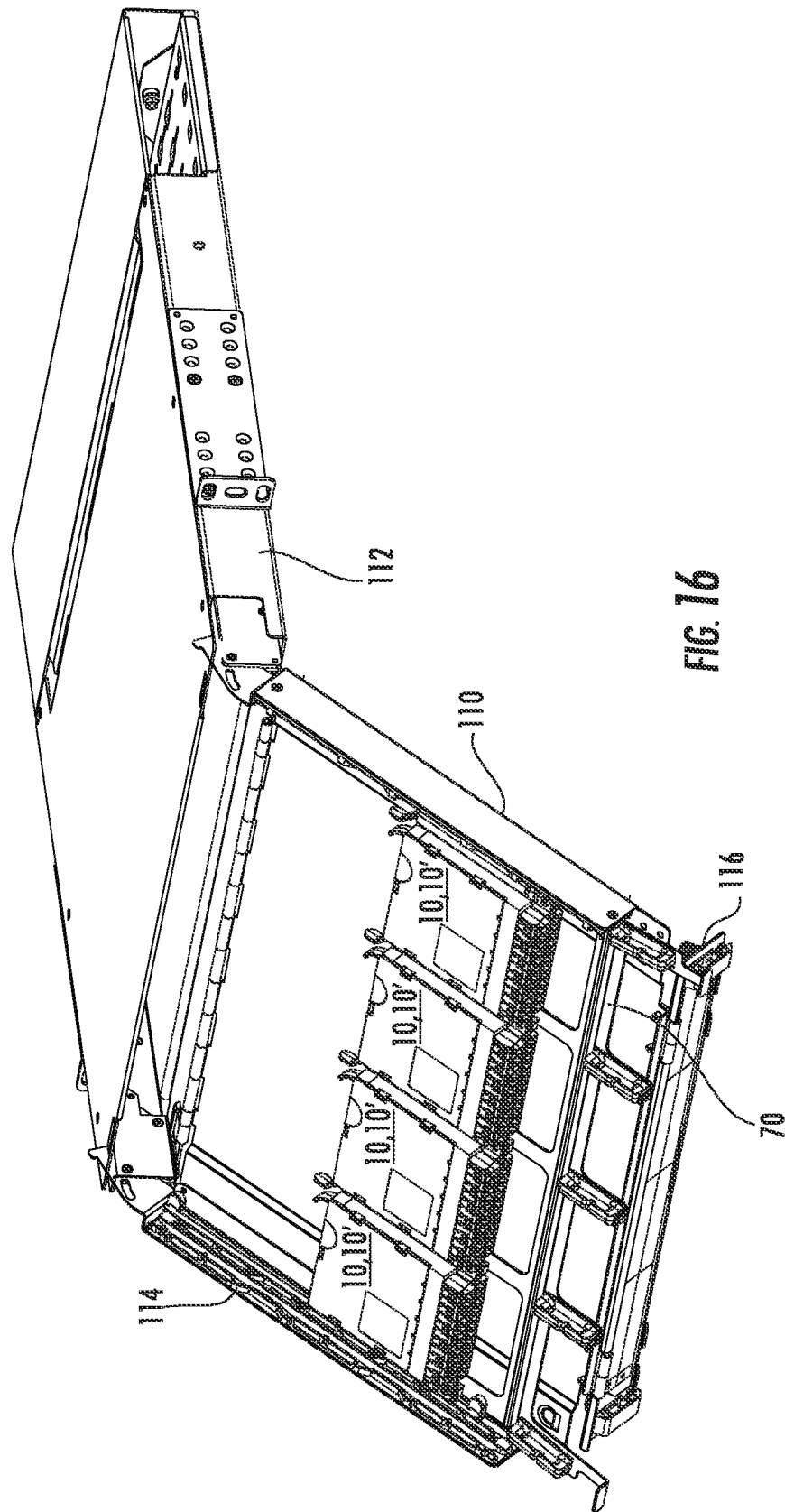


FIG. 14





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# STACKED FIBER OPTIC MODULES AND FIBER OPTIC EQUIPMENT CONFIGURED TO SUPPORT STACKED FIBER OPTIC MODULES

## RELATED APPLICATIONS

The present application claims priority to U.S. Provisional Patent Application Ser. No. 61/408,196 filed Oct. 29, 2010, entitled "Stacked Fiber Optic Modules and Fiber Optic Equipment Configured to Support Stacked Fiber Optic Modules," the disclosure of which is relied upon and incorporated herein by reference in its entirety.

## BACKGROUND

### 1. Field of the Disclosure

The technology of the disclosure relates to fiber optic modules and related fiber optic equipment to support and manage fiber optic connections.

### 2. Technical Background

Benefits of optical fiber include extremely wide bandwidth and low noise transmission. Because of these advantages, optical fiber is increasingly being used for a variety of applications, including but not limited to broadband voice, video, and data transmission. Fiber optic networks employing optical fiber are being developed and used to deliver voice, video, and data transmissions to subscribers over both private and public networks. These fiber optic networks often include separated connection points linking optical fibers to provide "live fiber" from one connection point to another connection point. In this regard, fiber optic connection equipment, which is also referred to as fiber optic equipment, is located in data distribution centers or central offices to support interconnections.

The fiber optic equipment is customized based on application need. The fiber optic equipment is typically included in housings that are mounted in equipment racks for organizational purposes and to optimize use of space. One example of such fiber optic equipment is a fiber optic module. A fiber optic module is designed to provide cable-to-cable fiber optic connections and manage the polarity of fiber optic cable connections. A fiber optic module is typically mounted to a chassis or housing which is then mounted inside an equipment rack or cabinet. A technician establishes fiber optic connections to the fiber optic modules mounted in the equipment rack. Due to increasing bandwidth needs and the need to provide a larger number of connections in data centers for increased revenue generating opportunities, a need exists to provide fiber optic modules that can facilitate larger numbers of fiber optic connections in a given space.

## SUMMARY OF THE DETAILED DESCRIPTION

Embodiments disclosed in the detailed description include stacked fiber optic modules and fiber optic equipment supporting stacked fiber optic modules. In one embodiment, a stacked fiber optic module is provided. This embodiment of the stacked fiber optic module comprises a body having at least one front side and at least one rear side and defining at least one internal chamber disposed between the at least one front side and the at least one rear side. The stacked fiber optic module further comprises a first plurality of fiber optic components disposed in a first longitudinal axis in the at least one front side. The stacked fiber optic module also further comprises a second plurality of fiber optic components disposed adjacent the first plurality of fiber optic components in a

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second longitudinal axis parallel or substantially parallel to the first longitudinal axis in the at least one front side. Fiber optic equipment supporting stacked fiber optic modules can include, without limitation, fiber optic equipment trays, housings, chassis, and drawers.

Additional features and advantages will be set forth in the detailed description which follows, and in part will be readily apparent to those skilled in the art from that description or recognized by practicing the invention as described herein, including the detailed description that follows, the claims, as well as the appended drawings.

It is to be understood that both the foregoing general description and the following detailed description present embodiments, and are intended to provide an overview or framework for understanding the nature and character of the disclosure. The accompanying drawings are included to provide a further understanding, and are incorporated into and constitute a part of this specification. The drawings illustrate various embodiments, and together with the description serve to explain the principles and operation of the concepts disclosed.

## BRIEF DESCRIPTION OF THE FIGURES

FIG. 1 is a front left perspective view of an exemplary stacked fiber optic module;

FIG. 2 is a perspective, exploded view of the exemplary stacked fiber optic module in FIG. 1;

FIGS. 3A and 3B are rear right perspective and side views, respectively, of the exemplary stacked fiber optic module of FIG. 1;

FIG. 3C is a rear view of the exemplary stacked fiber optic module of FIG. 1;

FIG. 4 is a perspective, exploded view of an alternative exemplary stacked fiber optic module having removable and/or sliding sub-bodies;

FIGS. 5A and 5B are bottom perspective and front views, respectively, of the top sub-body of the alternative exemplary stacked fiber optic module of FIG. 4;

FIGS. 6A and 6B are side perspective views of the alternative exemplary stacked fiber optic module of FIG. 4 prior to and after the top sub-body being attached to the bottom sub-body, respectively;

FIG. 6C is a front cross-sectional view the alternative exemplary stacked fiber optic module of FIG. 4 with the top sub-body attached to the bottom sub-body;

FIGS. 7A-7C are front right perspective and side views, respectively, of the exemplary alternative stacked fiber optic module of FIG. 4;

FIG. 8 is a front perspective view of one fiber optic equipment tray with installed stacked fiber optic modules configured to be installed in a chassis;

FIG. 9 is a front perspective view of the fiber optic equipment tray of FIG. 8 without stacked fiber optic modules installed therein;

FIG. 10 is a close-up view of the fiber optic equipment tray of FIG. 8 with fiber optic modules installed therein;

FIG. 11 is a front perspective view of an exemplary fiber optic equipment rack with an installed exemplary 1-U size chassis supporting fiber optic equipment trays of FIG. 6 each supporting stacked fiber optic modules;

FIGS. 12A and 12B are front perspective views of an alternate exemplary 4-U size chassis that can support the fiber optic equipment trays and stacked fiber optic modules according to the fiber optic equipment tray and fiber optic modules disclosed;

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FIG. 13 is a front perspective view of the 4-U size chassis of FIGS. 12A and 12B with a fiber optic equipment tray supporting stacked fiber optic modules pulled out from the fiber optic equipment tray;

FIG. 14 is a front perspective view of an exemplary fiber optic equipment drawer installed in a chassis and supporting fiber optic equipment trays supporting stacked fiber optic modules, according to another embodiment;

FIG. 15 is a front perspective view of an exemplary fiber optic equipment tray supported by the fiber optic equipment drawer of FIG. 14 and pulled out from the fiber optic equipment drawer; and

FIG. 16 is a front perspective view of the fiber optic equipment drawer of FIG. 14 fully pulled out from the chassis and tilted downward.

#### DETAILED DESCRIPTION OF THE EMBODIMENTS

Reference will now be made in detail to certain embodiments, examples of which are illustrated in the accompanying drawings, in which some, but not all features are shown. Indeed, embodiments disclosed herein may be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are provided so that this disclosure will satisfy applicable legal requirements. Whenever possible, like reference numbers will be used to refer to like components or parts.

Embodiments disclosed in the detailed description include stacked fiber optic modules and fiber optic equipment supporting stacked fiber optic modules. In one embodiment, a stacked fiber optic module is provided. This embodiment of the stacked fiber optic module comprises a body having at least one front side and at least one rear side and defining at least one internal chamber disposed between the at least one front side and the at least one rear side. The stacked fiber optic module further comprises a first plurality of fiber optic components disposed in a first longitudinal axis in the at least one front side. The stacked fiber optic module also further comprises a second plurality of fiber optic components disposed adjacent the first plurality of fiber optic components in a second longitudinal axis parallel or substantially parallel to the first longitudinal axis in the at least one front side. Fiber optic equipment supporting stacked fiber optic modules can include, without limitation, fiber optic equipment trays, housings, chassis, and drawers.

In this regard, FIG. 1 is a front left perspective view of an exemplary stacked fiber optic module 10. FIG. 2 illustrates a perspective, exploded view of the stacked fiber optic module 10 in FIG. 1. As illustrated in FIGS. 1 and 2, the stacked fiber optic module 10 is comprised of a body 12 receiving a cover 14. The body 12 has a front side 16 and a rear side 18 and defines an internal chamber 20 (FIG. 2) disposed between the front side 16 and rear side 18. The internal chamber 20 is configured to receive or retain optical fibers or a fiber optic cable harness 22 (FIG. 2) for establishing connections and maintaining desired polarity for first and second pluralities of fiber optic components 24, 26. The first plurality of fiber optic components 24 is disposed in a first longitudinal axis  $A_1$  in the front side 16 of the body 12. The second plurality of fiber optic components 26 is disposed adjacent the first plurality of fiber optic components 24 in a second longitudinal axis  $A_2$  parallel or substantially parallel to the first longitudinal axis  $A_1$  in the front side 16. In this manner, the stacked fiber optic module 10 is configured to support a great number and/or density of fiber optic components in a given body 12 size or

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space. The stacked fiber optic module 10 may be employed in high-density fiber optic connection applications.

In this example, the first and second pluralities of fiber optic components 24, 26 are duplex LC fiber optic adapters that are configured to receive and support connections with duplex LC fiber optic connectors. However, any fiber optic connection type desired can be provided in the fiber optic module 10. As illustrated in FIG. 3A, the first and second pluralities of fiber optic components 24, 26 are connected to a fiber optic component 28 disposed through the rear side 18 of the body 12. In this manner, a connection to the first and second pluralities of fiber optic components 24, 26 creates a fiber optic connection to the fiber optic component 28. In this example, the fiber optic component 28 is a multi-fiber MPO fiber optic adapter equipped to establish connections to multiple optical fibers (e.g., either twelve (12) or twenty-four (24) optical fibers). For example, if the first and second pluralities of fiber optic components 24, 26 provide twenty-four (24) connections, the fiber optic component 28 may be a twenty-four (24) optical fiber MPO fiber optic adapter to support the connections being provided to a fiber optic cable connected to the MPO fiber optic adapter.

In this example as illustrated in FIGS. 1 and 2, to provide for both the first and second pluralities of fiber optic components 24, 26 to be supported by the stacked fiber optic module 10, the body 12 is comprised of two sub-bodies. A first or bottom sub-body 30 supports the first plurality of fiber optic components 24, and a second or top sub-body 32 supports the second plurality of fiber optic components 26. The second sub-body 32 is disposed or "stacked" on top or adjacent to the first sub-body 30 in this example. The first and second sub-bodies 30, 32 may be provided as part of a single mold for the body 12. Alternatively, as will be discussed by example below with regard to FIGS. 4-7C, the first and second sub-bodies 30, 32 may be cast from two separate molds, wherein the first and second sub-bodies 30, 32 are secured to each other either permanently or in a removable manner.

With reference back to FIG. 2, the stacked fiber optic module 10 provides that the first plurality of fiber optic components 24 is disposed in the first sub-body 30 in a first front opening 34 disposed in the first longitudinal axis  $A_1$  in the front side 16 of the body 12. Similarly, the second plurality of fiber optic components 26 is disposed in the second sub-body 32 in a second front opening 36 disposed in the second longitudinal axis  $A_2$  in the front side 16 of the body 12. In this example of the stacked fiber optic module 10, as illustrated in FIG. 3B, the first front opening 34 is disposed in the same plane or substantially the same plane as the second front opening 36. This arrangement provides that the first plurality of fiber optic components 24 is disposed in the same front plane or substantially the same front plane  $P_1$  as the second plurality of fiber optic components 26. As will be discussed in more detail below, other options are possible wherein a stacked fiber optic module is provided that supports a first plurality of fiber optic components disposed in a different plane from a second plurality of fiber optic components.

With continuing reference to FIG. 2, in this example of the stacked fiber optic module 10, the cover 14 is configured to engage with the second sub-body 32. In this regard, tabs 38 are disposed in the second sub-body 32 and configured to engage with complementary detents 39 disposed on the cover 14 to secure the cover 14 to the second sub-body 32 when engaged thereto.

With continuing reference to FIGS. 1-3B, module rails 40A, 40B are disposed on each side 42A, 42B of the stacked fiber optic module 10. In this example, the module rails 40A, 40B are disposed on each side 42A, 42B of the first sub-body

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30. As will be discussed in more detail below, the module rails 40A, 40B are configured to be inserted within the module rail guides (not shown) in the fiber optic equipment to support the stacked fiber optic module 10. In this manner, when it is desired to install the stacked fiber optic module 10 in the fiber optic equipment, either the front side 14 or the rear side 16 of the stacked fiber optic module 10 can be first inserted into the module rail guides of a fiber optic equipment tray to dispose the module rails 40A, 40B in the module rail guides. A latch 44 containing a protrusion 46 is shown as being attached to the module rail 40A to allow the module rail 40A to be secured within a module rail guide.

The stacked fiber optic module 10 may also be configured to provide a certain density of fiber optic connections. In this regard, the stacked fiber optic module 10 may be provided of certain dimensions. For example, the stacked fiber optic module 10 may be provided wherein the first plurality of fiber optic components 24 is comprised of at least twelve (12) fiber optic connections disposed in a width  $W_1$  (FIG. 2) of the first front opening 34 of ninety (90) mm or less. Further, the stacked fiber optic module 10 may be provided wherein the second plurality of fiber optic components 26 is also comprised of at least twelve (12) fiber optic connections disposed in a width  $W_2$  (FIG. 2) of the second front opening 36 of ninety (90) mm or less. As another example, the first front opening 34 may be configured to support a fiber optic connection density of at least one fiber optic connection per 7.0 mm of width  $W_1$  of the first front opening 34. Likewise, the second front opening 36 may be configured to support a fiber optic connection density of at least one fiber optic connection per 7.0 mm of width  $W_2$  of the second front opening 36.

As discussed above, the first sub-body of a stacked fiber optic module may be provided as a separate component from a second sub-body of a stacked fiber optic module. The first sub-body and second sub-body may be configured to be permanently attached or be removeably attached. In this regard, FIGS. 4-7C discussed below provide an alternative exemplary stacked fiber optic module 10' wherein a first sub-body 30' is a separate component from the second sub-body 32' when disassembled and secured to each other when assembled. As will be discussed in more detail below, providing the first sub-body 30' as a separate component from the second sub-body 32' allows the first sub-body 30' to be slid about the second sub-body 32' to provide improved finger access to the fiber optic components 24, 26.

In this regard, FIG. 4 is a perspective, exploded view of the stacked fiber optic module 10' having the separate first sub-body 30' and second sub-body 32'. Other components provided in the stacked fiber optic module 10' that are common and/or provided in the stacked fiber optic module 10 in FIGS. 1-3C are shown in FIG. 4 with common element numbers and thus will not be described again. As illustrated in FIG. 4, the first sub-body 30' includes an internal chamber 50 that is configured to receive the fiber optic component 28 disposed through the rear side 18 of the body 12 and to store a cable harness connecting the fiber optic component 28 to the fiber optic components 24 and/or 26. A fiber guide 52 is disposed in the first sub-body 30' inside the internal chamber 50 to guide optical fibers from a cable harness. An internal chamber 54 is also disposed in the second sub-body 32'. To allow optical fibers from a cable harness connected to the fiber optic component 28 to be internally routed to the fiber optic connectors 24, 26 in both the first sub-body 30' and second sub-body 32', an opening 56 is disposed in a base 58 of the second sub-body 32'. The opening 56 connects the internal chambers 50, 54 when the second sub-body 32' is installed on the first sub-body 30'.

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Features are also provided in the first sub-body 30' and the second sub-body 32' to allow the first sub-body 30' and the second sub-body 32' to be easily connected together to form the stacked fiber optic module 10'. In this regard, as illustrated in FIG. 4 and the bottom and front views of the second sub-body 32' in FIGS. 5 and 6, respectively, the second sub-body 32' contains locking tabs 58A, 58B disposed on each side 42A, 42B. The locking tabs 58A, 58B are configured to engage with rails 60A, 60B, respectively, disposed inside the first sub-body 30'. As illustrated in FIG. 5B and the side cross-sectional view of the stacked fiber optic module 10' in FIG. 6A, the locking tabs 58A, 58B contain outwardly flared portions 62A, 62B. As illustrated in the side cross-sectional view of the stacked fiber optic module 10' in FIG. 6B, the outwardly flared portions 62A, 62B of the locking tabs 58A, 58B, respectively, are configured to interfere with and be pushed out from the rails 60A, 60B when the second sub-body 32' is alignedly disposed on top of the first sub-body 30' and the second sub-body 32' is pushed down on the first sub-body 30'. The outwardly flared portions 62A, 62B of the locking tabs 58A, 58B then move inwardly in a locking position when disposed below the rails 60A, 60B, as illustrated in the front cross-sectional view of the stacked fiber optic module 10' in FIG. 6C.

Providing the rails 60A, 60B in the first sub-body 30' to interlock the second sub-body 32' to the first sub-body 30' also allows the second sub-body 32' to be translated about the first sub-body 30' for improved access to the fiber optic components 24, 26, as illustrated in FIGS. 7A-7C. The locking tabs 58A, 58B can translate about the rails 60A, 60B to allow the second sub-body 32' to be translated about the first sub-body 30' in the depth direction, as illustrated in FIGS. 7A-7C.

In this regard, FIGS. 7A-7C illustrate front right perspective and side views, respectively, of the stacked fiber optic module 10'. As illustrated in FIG. 7B, the first plurality of fiber optic components 24 is disposed in a different front plane from the second plurality of fiber optic components 26 when the second sub-body 32' is translated back about the first sub-body 30'. In this regard, the first plurality of fiber optic components 24 is disposed in a front plane  $P_2$ , which is disposed forward of a front plane  $P_3$  where the second plurality of fiber optic components 26 is disposed. This may improve finger access to the first plurality of fiber optic components 24 by providing the first plurality of fiber optic components 24 in a different front plane from the second plurality of fiber optic components 26. This is because the first plurality of fiber optic components 24 is disposed forward of the second plurality of fiber optic components 26, such that the second plurality of fiber optic components 26 does not intrude access to the first plurality of fiber optic components 24, and vice versa. By way of example, a distance  $D$  that front plane  $P_2$  extends beyond front plane  $P_3$  is about 10 millimeters or more or vice versa as discussed below.

FIG. 7C is a side view of the stacked fiber optic module 10' where the second sub-body 32' is disposed forward of the first sub-body 30', to provide improved finger access to the second plurality of fiber optic components 26. As illustrated in FIG. 7C, the first plurality of fiber optic components 24 is disposed in a different front plane from the second plurality of fiber optic components 26 in the stacked fiber optic module 10' in FIGS. 7A and 7B. The first plurality of fiber optic components 24 is disposed in the front plane  $P_3$ , which is disposed behind the front plane  $P_2$  where the second plurality of fiber optic components 26 is disposed. This may improve finger access to the first plurality of fiber optic components 24 and second plurality of fiber optic components 26. Because the first plurality of fiber optic components 24 is disposed behind the

second plurality of fiber optic components 26, the first plurality of fiber optic components 24 does not intrude access to the second plurality of fiber optic components 26, and vice versa.

The stacked fiber optic modules 10, 10' can be configured to be disposed in a variety of different types of fiber optic equipment. For example, FIG. 8 is a front perspective view of a fiber optic equipment tray 70 supporting installed stacked fiber optic modules 10, 10' therein. The module rails 40A, 40B (FIGS. 1-7C) of the stacked fiber optic modules 10, 10' are inserted in module rail guides 72 disposed in the fiber optic equipment tray 70. Each module rail guide 72 includes a guide 73 to receive the module rails 40A, 40B, as illustrated in the unloaded fiber optic equipment tray 70 in FIG. 10. Note that any number of module rail guides 72 can be provided. The stacked fiber optic modules 10, 10' can be installed from both a front end 74 and a rear end 74 of the fiber optic equipment tray 70 in this embodiment. The stacked fiber optic modules 10, 10' can then be pushed within the module rail guides 72.

The stacked fiber optic modules 10, 10' can be moved towards the front end 74 until the stacked fiber optic modules 10, 10' reach a locking feature 78 disposed in the front end 34, as illustrated in the close-up view of the fiber optic equipment tray 70 in FIG. 10. The locking features 78 each include a stop 80. The stop 80 prevents the stacked fiber optic modules 10, 10' from extending beyond the front end 74. When it is desired to remove a stacked fiber optic module 10, 10' from the fiber optic equipment tray 70, the locking feature 78 can be engaged wherein the stop 80 will move downward away from the stacked fiber optic module 10, 10' such that the stacked fiber optic module 10, 10' is not obstructed from being pulled forward. The stacked fiber optic module 10, 10', and in particular its module rails 40A, 40B (FIGS. 1-7C), can be pulled forward along the module rail guides 72 to remove the stacked fiber optic module 10, 10' from the fiber optic equipment tray 70.

The stacked fiber optic module 10, 10' can also be removed from the rear end 76 of the fiber optic equipment tray 70. To remove the stacked fiber optic module 10, 10' from the rear end 76 of the fiber optic equipment tray 70, the protrusion 46 disposed in the module rails 40A, 40B is disengaged by pushing the latch 44 (FIGS. 1-7C) inward towards the stacked fiber optic module 10, 10' to release the protrusion 46 from the module rail guide 72.

With continuing reference to FIGS. 8-10, the fiber optic equipment tray 70 may also contain extension members 82. Routing guides 84 may be conveniently disposed on the extension members 82 to provide routing for optical fibers or fiber optic cables connected to the first and second pluralities of fiber optic components 24, 26 disposed in the stacked fiber optic modules 10, 10' (FIG. 10). The routing guides 84 on the ends of the fiber optic equipment tray 70 may be angled with respect to the module rail guides 72 to route optical fibers or fiber optic cables at an angle to the sides of the fiber optic equipment tray 70. Pull tabs 86 may also be connected to the extension members 82 to provide a means to allow tray guide rails 88 (FIG. 9) disposed in the fiber optic equipment tray 70 to be easily pulled out from a chassis, as will be described in more detail below.

The fiber optic equipment trays 70 in FIGS. 8-10 that support one or more of the stacked fiber optic modules 10, 10' are configured to be installed in a chassis or other fiber optic equipment. In this regard, FIG. 11 is a front perspective view of an exemplary fiber optic equipment rack 90 with an installed exemplary 1-U size chassis supporting the fiber

optic equipment trays 70 of FIGS. 8-10 each supporting stacked fiber optic modules 10, 10'.

In this regard, FIG. 11 illustrates exemplary 1-U or 1-RU size fiber optic equipment 92 from a front perspective view. The fiber optic equipment 92 may be provided at a data distribution center or central office to support cable-to-cable fiber optic connections and to manage a plurality of fiber optic cable connections. As shown in FIG. 11, the fiber optic equipment 92 supports one or more of the fiber optic equipment trays 70 that each support one or more of stacked fiber optic modules 10, 10'. In addition, the fiber optic equipment 92 could also be adapted to support one or more fiber optic patch panels or other fiber optic equipment that supports fiber optic components and connectivity.

With continuing reference to FIG. 11, the fiber optic equipment 92 includes a fiber optic equipment chassis 94 (also referred to herein a "chassis 94"). The chassis 94 is shown as being installed in the fiber optic equipment rack 90. The fiber optic equipment rack 90 contains two vertical rails 96A, 96B that extend vertically and include a series of apertures 98 for facilitating attachment of the chassis 94 inside the fiber optic equipment rack 90. The chassis 94 is attached and supported by the fiber optic equipment rack 90 in the form of shelves that are stacked on top of each other within the vertical rails 96A, 96B. The tray guide rails 88 of the fiber optic equipment trays 70 previously described with regard to FIGS. 8-10 can be inserted into tray rail guides 97 disposed in the chassis 94 to allow each fiber optic equipment tray 70 to be independently extended out from and retracted back into the chassis 94. As illustrated, the chassis 94 is attached to the vertical rails 96A, 96B. The fiber optic equipment rack 90 may support 1-U or 1-RU-sized shelves, with "U" or "RU" equal to a standard 1.75 inches in height and nineteen (19) inches in width. In certain applications, the width of "U" may be twenty-three (23) inches. In this embodiment, the chassis 94 is 1-U in size; however, the chassis 94 could be provided in a size greater than 1-U as well.

Up to three (3) fiber optic equipment trays 70 can be supported by the chassis 94. However, only one of the fiber optic equipment trays 70 provided in the chassis 94 can support stacked fiber optic modules 10, 10' due to the additional space consumed by the stacked fiber optic modules 10, 10'. In this regard, two (2) of such fiber optic equipment trays 70 can be provided in the chassis 94 if stacked fiber optic modules 10, 10' are included. In this scenario, one fiber optic equipment tray 70 supported in the chassis 94 could contain stacked fiber optic modules 10, 10', and the second fiber optic equipment tray 70 could support non-stacked fiber optic modules 10, 10' that have the height of one of the sub-bodies 30, 32 of the stacked fiber optic module 10, 10' (FIGS. 1-7C). The total count of fiber optic connections that can be supported by the chassis 94 is not reduced in any of these configurations.

Chassis sizes other than 1-U are possible. For example, FIGS. 12A and 12B are front perspective views of an alternate exemplary 4-U size chassis 100 that can support the fiber optic equipment trays 70 of FIGS. 8-10 supporting stacked fiber optic modules 10, 10'. The chassis 100 is a 4-U sized chassis and is configured to hold the fiber optic equipment trays 70 each supporting one or more stacked fiber optic modules 10, 10'. The tray guide rails 88 of the fiber optic equipment trays 70 previously described with regard to FIGS. 8-10 can be inserted into tray rail guides 102 (FIG. 12B) disposed in the chassis 100 to allow each fiber optic equipment tray 70 to be independently extended out from and retracted back into the chassis 100, as illustrated in FIG. 13. A front door 104 is attached to the chassis 100 and is configured to close about the chassis 100 to secure the fiber optic equip-

ment trays 70 disposed in the chassis 100. A cover 108 is also attached to the chassis 100, as illustrated in FIG. 12A, to secure the fiber optic equipment trays 70. FIG. 12B illustrates the chassis 100 with the cover 108 removed.

Up to twelve (12) fiber optic equipment trays 70 can be supported by the chassis 100. However, if the fiber optic equipment trays 70 support stacked fiber optic modules 10, 10', due to the additional space consumed by the stacked fiber optic modules 10, 10', six (6) of such fiber optic equipment trays 70 can be provided in the chassis 100 if all six (6) such fiber optic equipment trays 70 support stacked fiber optic modules 10, 10'. Each fiber optic equipment tray 70 disposed in the chassis 100 that includes at least one stacked fiber optic module 10, 10' reduces the total number of fiber optic equipment trays 70 that can be supported by the chassis 100 by two (2). However, the total count of fiber optic connections that can be supported by the chassis 100 is not reduced in any of these configurations.

FIG. 14 illustrates alternate exemplary fiber optic equipment that can support the fiber optic equipment trays 70, which can support the stacked fiber optic modules 10, 10'. In this regard, FIG. 14 illustrates a front perspective view of a fiber optic equipment drawer 110 (also referred to herein as "drawer 110") installed in a chassis 112 and supporting fiber optic equipment trays 70 supporting stacked fiber optic modules 10, 10'. FIG. 15 is a close-up view of FIG. 14.

The chassis 112 includes the drawer 110 supporting one or more extendable fiber optic equipment trays 70. Each fiber optic equipment tray 70 supported by the drawer 110 is independently translatable from the drawer 110, whether or not the drawer 110 is extended out from the chassis 112 or tilted downward, as illustrated in FIG. 16. The fiber optic equipment trays 70 can be moved and extended from the drawer 110 and refracted back into the drawer 110. Any number of fiber optic equipment trays 70 can be provided. Each fiber optic equipment tray 70 supports one or more of the stacked fiber optic modules 10, 10'. The drawer 110 is extendable out from the chassis 112 to allow improved access to the fiber optic equipment trays 70 and the stacked fiber optic modules 10, 10' supported therein.

The chassis 112 is a 1-U sized chassis and is configured to hold the fiber optic equipment trays 70 each supporting one or more stacked fiber optic modules 10, 10'. The tray guide rails 88 of the fiber optic equipment trays 70 previously described with regard to FIGS. 8-10 can be inserted into tray rail guides 114 disposed in the drawer 110, as illustrated in FIGS. 15 and 16, to allow each fiber optic equipment tray 70 to be independently extended out from and retracted back into the drawer 110. A front door 116 is attached to the drawer 110 and is configured to close about the drawer 110 to secure the fiber optic equipment trays 70 and fiber optic modules disposed therein in the drawer 110.

In the example of the drawer 110 in FIG. 14, one (1) fiber optic equipment tray 70 is supported. This is because although the drawer 110 can support up to two (2) fiber optic equipment trays 70, the stacked fiber optic modules 10, 10' consume space needed for a second fiber optic equipment tray 70. If only non-stacked fiber optic modules were supported, two (2) fiber optic equipment trays 70 could be supported in the chassis 112. The number of fiber optic connections supported by the drawer 110, however, is not reduced.

Many modifications and other embodiments of the invention set forth herein will come to mind to one skilled in the art to which the invention pertains having the benefit of the teachings presented in the foregoing descriptions and the associated drawings. These modifications include, but are not limited to, the number and type of fiber optic components

provided in the stacked fiber optic module, the configuration and/or alignment of bodies or sub-bodies of the stacked fiber optic module, the number or type of fiber optic equipment, the number and type of fiber optic module, the number and type of fiber optic equipment tray, and features included in the fiber optic equipment tray. Any size equipment, including but not limited to 1-U, 2-U and 4-U sizes, may include some or all of the aforementioned features and fiber optic modules disclosed herein and some or all of their features. Further, the modifications are not limited to the type of fiber optic equipment tray or the means or device to support fiber optic modules installed in the fiber optic equipment trays. The fiber optic modules can include any fiber optic connection type, including but not limited to fiber optic connectors and adapters, and number of fiber optic connections, density, etc.

Further, as used herein, it is intended that terms "fiber optic cables" and/or "optical fibers" include all types of single mode and multi-mode light waveguides, including one or more optical fibers that may be upcoated, colored, buffered, ribbonized and/or have other organizing or protective structure in a cable such as one or more tubes, strength members, jackets or the like. Likewise, other types of suitable optical fibers include bend-insensitive optical fibers, or any other expedient of a medium for transmitting light signals. An example of a bend-insensitive, or bend resistant, optical fiber is ClearCurve® Multimode fiber commercially available from Corning Incorporated. Suitable fibers of this type are disclosed, for example, in U.S. Patent Application Publication Nos. 2008/0166094 and 2009/0169163.

Therefore, it is to be understood that the embodiments are not to be limited to the specific embodiments disclosed and that modifications and other embodiments are intended to be included within the scope of the appended claims. It is intended that the embodiments cover the modifications and variations of this invention provided they come within the scope of the appended claims and their equivalents. Although specific terms are employed herein, they are used in a generic and descriptive sense only and not for purposes of limitation.

What is claimed is:

1. A stacked fiber optic module, comprising: a body having at least one front side and at least one rear side and defining at least one internal chamber disposed between the at least one front side and the at least one rear side, the body further comprised of a second sub-body engaged on top of a first sub-body to secure the second sub-body to the first sub-body, wherein the second sub-body can translate relative to the first sub-body; a first plurality of fiber optic components disposed in a first longitudinal axis in the at least one front side of the first sub-body; and a second plurality of fiber optic components disposed adjacent the first plurality of fiber optic components in a second longitudinal axis parallel or substantially parallel to the first longitudinal axis in the at least one front side of the second sub-body wherein the first plurality of fiber optic components is comprised of at least twelve (12) fiber optic connections disposed in a width of the first front opening of ninety (90) mm or less; and the second plurality of fiber optic components is comprised of at least (12) fiber optic connections disposed in a width of the second front opening of ninety (90) mm or less.

2. The stacked fiber optic module of claim 1, wherein the front side of the second sub-body can translate a distance of about 10 millimeters beyond the front side of the first sub-body or vice versa.

3. The stacked fiber optic module of claim 1, wherein the first plurality of fiber optic components is configured to be disposed in a different plane as the second plurality of fiber optic components.



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4. The stacked fiber optic module of claim 1, wherein the first plurality of fiber optic components are disposed in a first front opening disposed along the first longitudinal axis in the at least one front side of the body.

5. The stacked fiber optic module of claim 4, wherein the second plurality of fiber optic components are disposed in a second front opening disposed along the second longitudinal axis in the at least one front side of the body.

6. The stacked fiber optic module of claim 5, wherein the first front opening is configured to be disposed in a same plane or substantially the same plane as the second front opening.

7. The stacked fiber optic module of claim 1, wherein the first sub-body and the second sub-body are provided as separated bodies.

8. The stacked fiber optic module of claim 1, further comprising at least one locking tab disposed in the second sub-body configured to engage with at least one rail disposed in the first sub-body to secure the second sub-body to the first sub-body.

9. The stacked fiber optic module of claim 8, wherein the at least one locking tab is configured to translate about the at least one rail to allow the second sub-body to translate about the first sub-body.

10. The stacked fiber optic module of claim 1, further comprising at least one rail disposed on either the first sub-body or the second sub-body, and configured to be received within at least one guide member.

11. The stacked fiber optic module of claim 1, further comprising a cover disposed in either the first sub-body or the second sub-body.

12. The stacked fiber optic module of claim 1, further comprising at least one fiber optic component disposed through the at least one rear side of the body optically connected to at least one fiber optic component in at least one of the first plurality of fiber optic components and the second plurality of fiber optic components.

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13. The stacked fiber optic module of claim 1, wherein the first plurality of fiber optic components is comprised of a first plurality of fiber optic connectors or a first plurality of fiber optic adapters, and the second plurality of fiber optic components is comprised of a second plurality of fiber optic connectors or a second plurality of fiber optic adapters.

14. The stacked fiber optic module of claim 1, further comprising at least one rail disposed on the body configured to be received within at least one guide member.

15. The stacked fiber optic module of claim 14, further comprising at least one latch attached to the at least one rail and configured to engage the at least one rail.

16. The stacked fiber optic module of claim 1 disposed in fiber optic equipment comprised from the group consisting of a fiber optic chassis and a fiber optic equipment drawer.

17. The stacked fiber optic module of claim 5, wherein: the first front opening is configured to support a fiber optic connection density of at least one fiber optic connection per 7.0 mm of width of the first front opening; and the second front opening is configured to support a fiber optic connection density of at least one fiber optic connection per 7.0 mm of width of the second front opening.

18. The stacked fiber optic module of claim 1, further comprising at least one plurality of optical fibers disposed in the at least one internal chamber;

the at least one plurality of optical fibers optically connected to at least one of the first plurality of fiber optic components and the second plurality of fiber optic components.

19. The stacked fiber optic module of claim 18, wherein the at least one plurality of optical fibers are provided in at least one fiber optic harness disposed in the at least one internal chamber.

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